Attorney Docket No. SEL 233

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF APPEALS AND INTERFERENCES

In Re Application of:		)
	Shunpei YAMAZAKI et al.	)
Serial No.:	09/747,731	)
Filed:	December 22, 2000	)
For:	Method Of Manufacturing A Display Device	)
Examiner:	William P. Fletcher, III	)
Art Unit:	1762	)

APPEAL BRIEF UNDER 37 C.F.R. 41.37

Mark J. Murphy
Attorney for Appellants

COOK, ALEX, McFARRON, MANZO,
CUMMINGS & MEHLER, LTD.
200 West Adams Street, Suite 2850
Chicago, Illinois 60606
(312) 236-8500

Customer No. 26568

February 6, 2007

TABLE OF CONTENTS

TABLE OF AUTHORITIES

APPEAL BRIEF UNDER 37 C.F.R. §41.37

This Brief is in furtherance of the Notice of Appeal filed in this Application Serial No. 09/747,731 on November 6, 2006. A one-month extension of time being submitted herewith.

This appeal is in response to the Final Rejection of August 10, 2006 rejecting all the pending claims.

The claims of the present application are clearly patentable over the cited references, as will be shown *infra*, and Appellants respectfully request the Board to so rule and allow the application.

i. STATEMENT OF REAL PARTY IN INTEREST

The real party in interest in this appeal is the assignee: Semiconductor Energy Laboratory Co., Ltd., 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan.

ii. STATEMENT OF RELATED APPEALS AND INTERFERENCES

To the best of Appellants', Appellants' legal representatives' and Assignee's knowledge, there are no appeals or interferences pending which will affect or be affected by the Board's decision in this appeal.

iii. STATUS OF CLAIMS

Claims 20-22, 37-40, 43-45, 48, 49, 53-176 are pending and rejected. Claims 20-22, 37-40, 43-45, 48, 49, 53-176 are the appealed claims and appear *infra* at p. 49 *et seq*.

iv. STATUS OF AMENDMENTS

No amendment after final has been filed in this application.

v. SUMMARY OF CLAIMED SUBJECT MATTER

In accordance with §41.37(c)(v), Appellants are providing the following concise explanation of the claimed subject matter. Appellants are providing examples of where each claim element is shown or discussed in the specification and drawings of the present application. These citations are merely examples, as the application has further disclosure of these elements throughout the application.

The dependent claims are based, either directly or indirectly, on one of the independent claims, and accordingly, all the elements listed for the respective independent claims, and the support for these elements in the specification and drawings are as mentioned herein. These dependent claims also add additional elements or limitations which are supported in the specification and drawings.

Independent Claim 20 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in a first evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second evaporation chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second

direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the first evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material.

Independent Claim 37 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A))**

(page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5);

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber; and

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice.

Independent Claim 38 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber; and

repeatedly moving the relative position of the second evaporation source with respect

to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate **(Fig. 2A)**.

Independent Claim 39 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**; wherein the first evaporation source comprises a plurality of first evaporation cells arranged along a first direction;

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein the second evaporation source comprises a plurality of second evaporation cells;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)** so that the

plurality of second evaporation cells are arranged in the first direction;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber **(page 7, lines 3-7)**.

Independent Claim 40 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**; wherein the first evaporation source comprises a plurality of first evaporation cells arranged along a first direction;

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein the second evaporation source comprises a plurality of second evaporation cells;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first

material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along a second direction during the step of evaporating the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)**so that the plurality of second evaporation cells are arranged in the first direction;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber **(page 7, lines 3-7)**,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate **(Fig. 2A)**.

Independent Claim 54 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A))** **(page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber **(page 7, lines 3-7)**.

Independent Claim 55 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit said first material over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the second evaporation source from the second chamber into the

evaporation chamber after evaporating the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit said second material over the substrate **(page 10, lines 19-21)** in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber **(page 7, lines 3-7)**,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate **(Fig. 2A)**.

Independent Claim 81 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in a first evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second evaporation chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the first evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit a hole injecting layer over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material **(page 11, lines 11-13; Fig. 5)**; and

evaporating a second material from said second evaporation source to deposit a light emitting layer over the hole injecting layer wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material in the second evaporation chamber.

Independent Claim 85 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** in a first evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**;

providing a second evaporation source **(212)** in a second evaporation chamber **(201; 509(B)) (page 14, lines 8-16; Figs. 2A, 5)** wherein each of the first and second evaporation sources

has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the first evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from said first evaporation source to deposit a hole injecting layer over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)** in order that a same portion of the substrate is coated with the material at least twice **(page 5, lines 2-5; page 5, lines 14-15)**;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material **(page 11, lines 11-13; Fig. 5)**;

evaporating a second material from said second evaporation source to deposit a light emitting layer over the hole injecting layer wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material;

forming a conducting film by evaporation over the light emitting layer; and

sealing the light emitting layer by sealing material without exposure to the atmosphere.

Independent Claim 89 is directed to a method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source **(212)** and a second evaporation source **(212)** in an evaporation chamber **(201; 506(A); 509(B)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7, 8-16; Figs. 2A-5)**, wherein each of the first and second evaporation sources has a first direction and a second direction different from each other **(page 3, lines 22-26)**, each of the first and second evaporation sources **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the first evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a first material from the first evaporation source to deposit said first material over a first pixel portion of the substrate **(page 5, lines 6-10; page 10, lines 4-9)** in the evaporation chamber;

moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material **(page 4, lines 26-27; page 5, lines 1-5; page 10, lines 10-21)**;

moving the mask by one pixel portion **(page 10, lines 14-15)**;

evaporating a second material from said second evaporation source to deposit said second material over a second pixel portion in the evaporation chamber; and

moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material.

Independent Claim 92 is directed to a method of manufacturing an electroluminescence display device comprising:

providing an evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**, wherein the evaporation source has a first direction and a second direction different from each other **(page 3, lines 22-26)**, the evaporation source **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**; and

evaporating a material from the evaporation source to form a hole injecting layer over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material.

Independent Claim 95 is directed to a method of manufacturing an electroluminescence display device comprising:

providing an evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**, wherein

the evaporation source has a first direction and a second direction different from each other **(page 3, lines 22-26)**, the evaporation source **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**;

evaporating a material from said the evaporation source to form a light emitting layer over the substrate **(page 5, lines 6-10; page 10, lines 4-9)** wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material **(pages 5, lines 2-5, 14-15)**.

Independent Claim 98 is directed to a method of manufacturing an electroluminescence display device comprising:

providing an evaporation source **(212)** in an evaporation chamber **(201; 506(A)) (page 8, line 12; page 9, line 19; page 13, lines 5-7, 9-11; page 14, lines 5-7; Figs. 2A-5)**, wherein the evaporation source has a first direction and a second direction different from each other **(page 3, lines 22-26)**, the evaporation source **(212)** being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

evaporating a material from said evaporation source to form a light emitting layer comprising said material over the substrate wherein the relative position of the substrate is moved

with respect to the evaporation source during the evaporation of the material **(page 5, lines 2-5, 14-15)**.

Independent Claim 169 is directed to a method of manufacturing an electroluminescence display device comprising:

providing an evaporation source **(212)** in an evaporation chamber, wherein the evaporation source has a first direction and a second direction different from each other **(page 3, lines 22-26)**, the evaporation source being longer in the first direction than in the second direction **(page 4, lines 1-4; Fig. 2A)**;

disposing a substrate **(203)** in the evaporation chamber **(page 8, lines 12-17; Fig. 2A)**;

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the evaporation source **(page 8, lines 19-21; page 4, lines 12-15; Figure 2B)**; and

evaporating a material from said the evaporation source to form a light emitting layer over the substrate wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material **(page 5, lines 2-5, 14-15)**,

wherein the mask has at least a rectangular shaped open portion **(page 8, lines 23-25; Fig. 2A)**, and

wherein a longitudinal direction of open portion is perpendicular to the first direction of the evaporation source.

Claim 21 is dependent on Claim 20 and recites the method further comprising a step of

cleaning an inside of the first and second evaporation chambers, respectively **(page 7, lines 3-7)**.

Claim 22 is dependent on Claim 20 and recites that said first and second evaporation chambers are connected to each other through a conveyor chamber **(501) (page 11, lines 6-7; page 13, lines 7-8; page 14, lines 12-13; Fig. 5)**.

Claim 43 is dependent on Claim 37 and recites that said second direction is orthogonal to the first direction **(page 3, lines 22-25; Fig. 2A)**.

Claim 44 is dependent on Claim 20 and recites that the relative position of the first evaporation source is moved with respect to the substrate in a direction orthogonal to an elongation direction of the first evaporation source **(page 3, lines 22-25; Fig. 2A)**.

Claim 45 is dependent on Claim 20 and recites that the relative position of the second evaporation source is moved with respect to the substrate in a direction orthogonal to an elongation direction of the second evaporation source **(page 3, lines 22-25; Fig. 2A)**.

Claim 48 is dependent on Claims 20 and 37-40 and recites that at least one of the first and second materials comprises an organic material **(page 13, lines 5-6)**.

Claims 49, 59-62, 101 and 176 are dependent on Claims 20, 37-40, 98 and 169, respectively, and recite that said display device is an active matrix electroluminescence display device **(page 1,**

lines 12-15).

Claim 53 is dependent on Claims 37 and 39 and recites that the relative position of the first evaporation source is repeatedly moved with respect to the substrate so that a same portion of the substrate is coated with the first material at least twice **(page 5, lines 2-5, 14-15)**.

Claims 56-58 and 170 are dependent on Claims 38-40 and 169, respectively, and recite that said second direction is orthogonal to the first direction **(page 3, lines 22-25; Fig. 2A)**.

Claims 63-69 are dependent on Claims 20, 37-40, 54 and 55, respectively, and recite that uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation **(page 3, line 19 - page 4, line 1; page 6, lines 17-23; page 8, lines 22-24)**.

Claim 70 is dependent on Claim 20 and recites that said first and second evaporation chambers are connected with each other through at least one gate **(page 13, line 5; page 14, line 14; page 22, line 27 - page 23, line 1; Fig. 5)**.

Claims 71, 72 and 90 are dependent on Claims 54, 55 and 89, respectively, and recite that at least one of the first and second materials comprises an organic material **(page 13, lines 5-6)**.

Claim 73 is dependent on Claim 20 and recites that the mask fixed to a mask holder

approaches the substrate by a magnet field **(page 9, lines 1-5)**.

Claims 74-80, 84, 88 and 91 are dependent on Claims 20, 37-40, 54, 55, 81, 85 and 89, respectively, and recite that each of the first and second evaporation sources has a length exceeding 300 mm along the first direction **(page 4, lines 1-5; page 9, lines 8-9)**.

Claims 82, 86 and 93 are dependent on Claims 81, 85 and 92, respectively, and recite that the hole injecting layer comprises an organic material **(page 13, lines 17-18; page 18, line 27 - page 19, line 4)**.

Claims 83, 87 and 95 are dependent on Claims 81, 85 and 95, respectively, and recites that the light emitting layer comprises an organic material **(page 13, lines 5-6; page 18, line 27 - page 19, line 4)**.

Claims 94, 97 and 100 are dependent on Claims 92, 95 and 98, respectively, and recite that the evaporation source has a length exceeding 300 mm along the first direction **(page 4, lines 1-5; page 9, lines 8-9)**.

Claim 99 is dependent on Claim 98 and recites the method further comprising steps of:

fixing a mask **(208)** to the substrate wherein the mask is located between the substrate and the evaporation source **(page 8, lines 19-21; page 4, lines12-15; Fig. 2B)**.

Claims 102, 105, 108, 111, 114, 117, 120, 123, 126 and 129 are dependent on Claims 20, 37-40, 54, 55, 81, 85 and 89, respectively, and recite that the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate **(page 12, lines 13-20; Fig. 2B)**.

Claims 103, 106, 109, 112, 115, 118, 121, 124, 127, 130, 133, 136 and 139 are dependent on Claims 20, 37-40, 54, 55, 81, 85, 89, 92, 95 and 98, respectively, and recite that a lower surface of the substrate is provided with thin films **(page 5, lines 2-5; page 12, lines 16-18; Fig. 2B)**.

Claims 104, 107, 110, 113, 116, 119, 122, 125, 128, 131, 134, 137 and 140 are dependent on Claims 20, 37-40, 54, 55, 81, 85, 89, 92, 95 and 98, respectively, and recite that a lower surface of the substrate is provided with a transparent conducting film **(page 12, lines 9-18; Fig. 2B)**.

Claims 132, 135 and 138 are dependent on Claims 92, 95 and 98, respectively, and recite that the substrate is located above the evaporation source,

wherein the first material is formed on a lower surface of the substrate **(page 12, lines 13-20; Fig. 2B)**.

Claims 141, 143 and 173 are dependent on Claims 95, 98 and 169, respectively, and recite that said material is organic **(page 1, lines 18-19)**.

Claims 142, 144 and 174 are dependent on claims 95, 98 and 169, respectively, and recite that said material is inorganic **(page 1, lines 18-19)**.

Claims 145 and 149 are dependent on Claims 39 and 40, respectively, and recite that a gap between said first evaporation cells has a distance a and a distance between said first evaporation source and said mask is 2a to 100a **(page 6, lines 12-16)**.

Claims 146 and 150 are dependent on Claims 145 and 149, respectively, and recite that said distance between said first evaporation source and said mask is 5a to 50a **(page 6, lines 12-16)**.

Claims 147 and 151 are dependent on Claims 39 and 40, respectively, and recite that a gap between said second evaporation cells has a distance a and a distance between said second evaporation source and said mask is 2a to 100a **(page 6, lines 12-16)**.

Claims 148 and 152 are dependent on claims 147 and 151, respectively, and recite that said distance between said second evaporation source and said mask is 5a to 50a **(page 6, lines 12-16)**.

Claims 153-155 are dependent on Claims 38, 40 and 55, respectively, and recite that during evaporation each of the first and second evaporation sources moves from one end of the substrate to the other end **(page 4, lines 26-27; page 10, lines 4-5)**.

Claims 156-168 and 175 are dependent on Claims 20, 37-40, 54, 55, 81, 85, 89, 92, 95, 98

and 169 and recite that said display device is a passive matrix electroluminescence display device **(page 1, lines 14-15)**.

Claim 171 is dependent on Claim 169 and recites that said electroluminescence display device is a color display,

wherein the substrate is located above the evaporation source,

wherein a lower surface of the substrate is provided with thin films,

wherein thin films of materials for emitting different colors are formed for each pixel **(page 1, line 27; page 2, lines 1-2; page 4, lines 17-18; page 5, lines 6-9; page 12, lines 12-18; Fig. 2B)**.

Claims 172 is dependent on Claim 169 and recites that each of the evaporation sources has a length exceeding 300 mm along the first direction **(page 4, lines 1-5; page 9, lines 8-9)**.

vi. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The following are the grounds for rejection presented for review:

1. Claims 20-22, 44, 45, 48, 63, 70, 74 and 156 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. (US 5,817,366) in view of Grothe et al. (US 3,391,490), Monk (US 4,187,801) and Nagayama et al. (US 5,701,055).

2. Claims 37, 43, 48, 53, 64, 75 and 157 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Bennett (US 2,435,997), Grothe et al and Nagayama et al.

3. Claims 38, 48, 56, 65, 76, 153 and 158 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Bennett, Grothe et al., Nagayama et al. and Monk.

4. Claims 39, 48, 53, 57, 66, 77 and 159 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al. (US 4,627,989), Bennett, and Yamamoto et al. (JP 11-61386, US 6,179,923).

5. Claims 40, 48, 58, 67, 78, 154 and 160 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al., Bennett and Yamamoto et al. or in the alternative, over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk, and Yamamoto et al.

6. Claim 49 is rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al., and further in view of Spitzer et al. (US 5,258,325).

7. Claims 54, 68, 71, 79 and 161 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al. and Yamamoto et al.

8. Claims 55, 69, 72, 80, 155 and 162 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al., Monk, and Yamamoto et al.

9. Claim 59 is rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett and Grothe et al., further in view of Spitzer et al.

10. Claim 60 is rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al, and Monk, further in view of Spitzer et al.

11. Claim 61 is rejected under 35 USC §103(a) as being unpatentable over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al., and further in view of Spitzer et al.

12. Claim 62 is rejected under 35 USC §103(a) as being unpatentable over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al., or in the alternative, over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk, and Yamamoto et al. and further in view of Spitzer et al.

13. Claim 73 is rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al., further in view of Mizutani et al. (US 6,326,726).

14. Claims 81-88, 92-100, 141-144, 163, 164 ,166-168 and 169-176 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al.

15. Claims 89-91 and 165 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al.

16. Claim 101 is rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al., further in view of Spitzer.

17. Claims 102-104 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk, Nagayama et al. and further in view of Bertelsen (US 3,110,620).

18. Claims 105-107 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Bennett, Grothe et al., and Nagayama et al. and further in view of Bertelsen.

19. Claims 108-110 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Bennett, Grothe et al., Nagayama et al., and Monk and further in view of Bertelsen.

20. Claims 111-113 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Feurestein et al., Bennett, and Yamamoto et al. and further in view of Bertelsen.

21. Claims 114-116 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al. or in the alternative, over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk and Yamamoto et al. further in view of Bertelsen.

22. Claims 117-119 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al. and Yamamoto et al. further in view of Bertelsen.

23. Claims 120-122 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al., Monk and Yamamoto et al. further in view of Bertelsen.

24. Claims 123-128 and 132-138 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. further in view of Bertelsen.

25. Claims 129-131 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. further in view of Bertelsen.

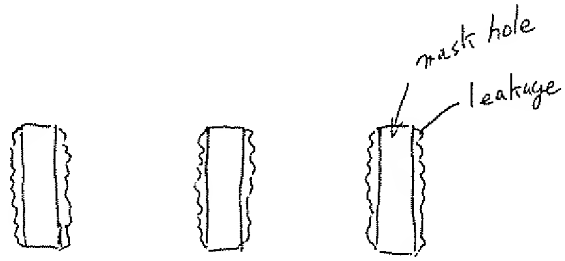
26. Claims 145-148 are rejected under 35 USC §103(a) as being unpatentable over Arai et al. in view of Nagayama et al. , Feuerstein et al., Bennett, and Yamamoto et al. and further in view of either Noguchi et al. (US 4,596,735) or Martin (US 4,469,719).

27. Claims 149-152 are rejected under 35 USC §103(a) as being unpatentable over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al., or in the alternative, over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk, and Yamamoto et al., further in view of either Noguchi et al. or Martin.

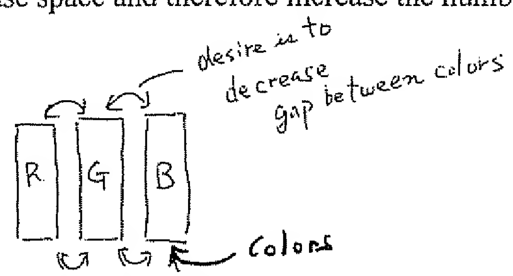
vii. ARGUMENT

A. BACKGROUND

The present invention is directed to a highly advantageous method for manufacturing a display device. In fact, with the claimed method, the uniformity of the film thickness can be greatly improved. In prior devices, the substrate and the mask are stationary, and it takes a considerable period of time to apply a layer. Because it takes so long to apply a layer, not only is the area within the mask hole coated, but the areas under the edges of the mask are also coated. This is considered leakage.



In contrast, with the claimed method, because of the relative movement of the substrate, the coating of the mask area does not require a very long period. As a result, there is minimal coating under the edges of the mask. This is a very important feature for increasing the number of pixels on a display which is very important for a high definition display. Further, it is desirable to decrease the gap between colors to decrease space and therefore increase the number of pixels.



However, if there is leakage (i.e. wherein the areas under the edges of the mask are also coated, as discussed above), a significant gap (space) has to be left between the colors to account for this leakage, and as a result, the space between the colors cannot be decreased. Accordingly, the

colors cannot be moved closer to one another, and the number of pixels cannot be increased. As a result, a high definition display is not possible.

As will be explained below, none of the cited references, either individually or combined, disclose all of the claimed features of the method of the claims of the present application, and none realize or recognize the above advantages and uniformity of the film resulting from the claimed method of the present invention. Therefore, since there is no recognition of these advantages stemming from the claimed method, one skilled in the art would not have combined the cited references in the manner proposed by the Examiner to realize these advantages and arrive at the claimed invention nor would one have any reason to combine these references to arrive at the claimed method, other than by improper hindsight reconstruction. Accordingly, the combination of references and the rejections based thereon are improper and should be reversed.

Appellants will now address the pending rejections of the claims in the Final Rejection.

B. <u>THE REJECTIONS OF THE CLAIMS SHOULD BE REVERSED</u>

Each of the Examiner's pending rejections is a Section 103(a) rejection for obviousness over four or more references. As will be shown below, each of these rejections is improper as a prima facie case of obviousness has not been established, and even if a prima facie case has been established, such a prima facie case has clearly been rebutted.

1. A PRIMA FACIE CASE OF OBVIOUSNESS CANNOT BE BASED ON HINDSIGHT RECONSTRUCTION

Under 35 U.S.C. §103, the burden is on the PTO to produce evidence that the claimed invention is prima facie obvious. In re Rijckaert, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993); In re Fine, 837 F.2d 1071, 1074, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). If the PTO fails to make out a prima facie case of obviousness, then the rejection is improper, should be overturned, and Applicants are entitled to a patent. Rijckaert, 9 F.3d at 1532, 28 USPQ2d at 1956; In re Nielson, 816 F.2d 1567, 1572, 2 USPQ2d 1525, 1528 (Fed. Cir. 1984); In re Gordon, 733 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984). A prima facie case of obviousness cannot be based on a combination of references wherein the combination of references is based on hindsight reconstruction using the claimed invention as a template. In re Fritch, 972 F.2d 1260, 1266 23 USPQ2d 1780, 1784 (Fed. Cir. 1992); In re Oetiker, 24 USPQ2d 1443, 1447 (Fed. Cir. 1992).

As explained below, in the present case, there can be no basis for combining the references as in the rejections in the Final Rejection to arrive at the claimed invention other than by hindsight reconstruction, using the independent claims of the present application as a blueprint.

As the Federal Circuit stated in McGinley v. Franklin Sports, Inc., 60 USPQ2d 1001, 1008 (Fed. Cir. 2001), "[t]he genius of invention is often a combination of known elements which in hindsight seems preordained." As a result, "[I]t is impermissible to use the claimed invention as an instructional manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious." In re Fritch, 972 F.2d at 1266, 23USPQ2d at 1784. "One cannot use hindsight reconstruction to pick and chose among isolated disclosures in the prior art to deprecate the claimed invention." In re Fine, 5 USPQ 2d 1596, 1600 (Fed. Cir. 1988).

Combining references in a manner that reconstructs the applicant's invention only with the benefit of hindsight, is insufficient to present a *prima facie* case of obviousness. In re Oetiker, 24 USPQ2d at 1444-1446 (Fed. Cir. 1992).

2. THE REJECTION OF INDEPENDENT CLAIM 20 AND THE CLAIMS DEPENDENT THEREON IS IMPROPER

The Examiner rejects independent Claim 20, and Claims 21-22, 44, 45, 48, 63, 70, 74 and 156 dependent thereon, under 35 USC §103(a) as being unpatentable over Arai et al. (US 5,817,366) in view of Grothe et al.[2], Monk (US 4,187,801) and Nagayama et al. (US 5,701,055). This rejection is improper and should be reversed.

In the Final Rejection, the Examiner states that these claims are rejected for the same reasons as set-forth under this heading in the prior Office action (which was the Office Action of February 22, 2006 which states that the rejections are the same as set forth in the Final Rejection of July 26, 2005); therefore, Appellants are referring back to 7-26-05 Final Rejection for the Examiner's basis for this rejection.

The basis for this rejection is an intricate combination of four different references to arrive at the claimed invention. As shown below, the combination of references used in the rejection to arrive at the claimed invention is based on improper hindsight reconstruction, and accordingly, the rejection based on this construction is improper and should be reversed. Further, Appellants can show

[2] Appellants assume that this is US Patent No. 3,931,490, as opposed to US 3,391,490 which is cited in the Final Rejection. U.S. 3,391,490 is to Evans for a Remotely Controlled Vehicle System. Appellants have informed the Examiner numerous times of this error, but the Examiner has yet to correct it.

evidence of the non-obviousness of the claimed invention.

a. The Rejection Is Based on Improper Hindsight Reconstruction

In the 7-26-05 Final Rejection (for which the most recent Final Rejection appears to rely) and in prior actions, the Examiner admits that Arai does not disclose a number of the claimed features of the rejected claims. The Examiner, however, contends that it would have been obvious to one of ordinary skill in the art to (1) modify the process of Arai so as to utilize as the evaporation source, the evaporation source of Grothe, and to (2) further modify the process of Arai so as to move the substrate and the evaporating sources relative to each other as allegedly taught by Monk. In the 7-26-05 Final Rejection (and adopted in the present Final Rejection), the Examiner continues to repeat these contentions and adds a further contention that it would have been obvious to one of ordinary skill in the art to (3) modify the process of Arai with the teachings from Nagayama so as to utilize a shadow mask, as recited in independent Claim 20, in the claimed fashion. Hence, it appears that the Examiner has taken Arai and modified it with three separate references, in three separate (and unrelated) steps. The Examiner does not include an explanation for why it would be obvious to one skilled in the art to modify Arai in such a manner to arrive at the claimed invention. Instead, as explained below, it appears that the Examiner has picked and chosen isolated elements from the references based on the claimed invention. Hence, Appellants respectively disagree with the Examiner's contentions and submit that this rejection and combination of references in the rejection are improper.

Independent Claim 20 is directed to a method of manufacturing an electroluminescence display device. As explained above, the claimed features as combined in the method of Claim 20

are advantageous, for example, for preventing leakage and providing more pixels for the display device. The result is a high definition display that was not previously possible.

None of the references disclose the claimed features as specifically combined in Claim 20 nor do the references recognize the advantages resulting from these claimed features. While the Examiner argues that the references do not have to be combined for the reasons contemplated by the inventor, it is still necessary to combine the references in a logical manner to one skilled in the art and provide evidence that one skilled in the art would combine the references in the same manner as the Examiner, without knowledge of the claimed invention. See e.g. Ecolochem, Inc. v. Southern California Edison Co., 227 F.3d 1361, 56 USPQ2d 1065, 1076 (Fed. Cir. 2000). In order to logically and legitimately combine references, the Examiner must consider the entire teachings in the references and cannot pick and choose among isolated teachings in the references to the exclusion of the other teachings in the reference. Bausch & Lomb, Inc. v. Barnes-Hind/Hydrocurve, Inc., 796 F.2d 443, 230 USPQ 416, 419-420 (Fed. Cir. 1986); In re Fine, supra. To do so is to engage in hindsight reconstruction. Id. As shown below, this is what the Examiner has done in the pending rejection.

i. The Combination of Arai and Grothe Is Improper

The Examiner admits that Arai does not disclose first and second evaporation sources having a first direction longer than the second direction, as recited in Claim 20. The Examiner cites to the evaporation source in Grothe and states that it would have been obvious to one of ordinary skill in the art to modify the process of Arai to use the evaporation source of Grothe and that one "would have been motivated to do so by the desire and expectation of achieving enhanced vapor density and

deposition uniformity, as taught by Grothe." However, as explained below, the Examiner's motivation is not valid and does not stand up to scrutiny. Further, one skilled in the art would not combine these references.

Initially, it is noted that the Examiner has selected an isolated sentence in Grothe on which to base his rejection. What Grothe actually states in the line in question is that "coating of wide surfaces, such as wide, running webs, ribbons and the like by vapor deposition requires high density of the vapor." See col. 5, lns. 41-43 in Grothe. Hence, Grothe discusses high vapor density and uniformity only with regard to wide, running webs or ribbons. Further, Grothe relates to coating of wide area work surfaces.

In contrast, Arai relates to a process and apparatus for manufacturing an organic electroluminescence cell or element, and more particularly to a process "wherein the steps after formation of a transparent electrode on a substrate plate up to formation of a protective film are successively carried out in vacuum chambers which are isolated from the oxidative external atmosphere and thereafter withdrawn from the chambers into the air." See Abstract in Arai. Hence, Arai relates to sealing of an organic electroluminescence cell.

Therefore, the coating of Grothe is not related to the sealing in Arai, and the Examiner's reason for combining the references is not related to the teachings in Arai. Hence, one skilled in the art would not use this as a reason to combine these references, and there is no motivation or reason for one skilled in the art to combine these unrelated technologies.

Further, the Examiner is basing his alleged motivation to combine Grothe and Arai on this statement, without consideration of the teachings in the remainder of the reference. For example, Grothe discloses applying substances, in a vacuum, on a work surface 21 particularly wide tapes,

webs, or the like. See col. 7, lns 9-10. Grothe also states that "the entire system is in vacuum, that is, enclosed in an evacuated vessel", and that "movement of the web 21 is preferably continuous." Col. 3, lns. 62-65. Hence, Grothe is not directed to a system involving, nor does it disclose or suggest, transferring a substrate between chambers, as in Arai and the claimed invention. Instead, Grothe appears to be one closed system. Based on the teachings in Grothe, one skilled in the art would not believe that the Grothe system is usable in a system involving transfer between chambers. The Examiner does not appear to have considered these teachings in Grothe when combining these references. Grothe also does not disclose or suggest connecting chambers. The Examiner also does not appear to have considered this lack of teaching. Further, Grothe also does not disclose or suggest transferring the web between chambers or how one could even transfer the web between chambers. Furthermore, there is nothing in Arai or Grothe to teach one skilled in the art as to how one could allegedly incorporate the device from Grothe in the device in Arai. Therefore, in light of the above teachings in Grothe, which appear to teach away from the subject matter of the present invention (directed to a method with multiple chambers), and the lack of teachings in Grothe relevant to the subject matter of Arai, there would have been no motivation for one skilled in the art to look at and select an isolated portion of Grothe and combine it with Arai to try to arrive at the claimed invention, except when using the claimed invention as a guideline (i.e. the Examiner looked at the claim and Arai, saw that Arai did not have evaporation sources being longer in a first direction than a second direction, searched for this specific feature in the references, allegedly found the specific feature, and then without regard to the other teachings in the references, decided to use that feature and combine the references).

The Examiner, however, argues that the test is not whether the features of a secondary

reference may be bodily incorporated into the structure of the primary reference but what the combined references would have suggested to those of ordinary skill in the art.

The Examiner, however, is missing the point. Before one can determine what the combined references would suggest, it must first be determined if the references can be combined. It is well established that in order to combine references, there must be some teaching, suggestion or motivation to do so and that the teachings in the references must be considered in their entirety, See In re Fine; Bausch & Lomb, supra. In this case, Arai and Grothe are directed to different systems. Arai is directed to a system with multiple chambers and sealing of an organic electroluminescence cell while Grothe is directed to a closed system in a vessel and for coating wide work area surfaces. There is no reason why one skilled in the art, after reviewing Arai, would look to Grothe to modify the system of Arai. The only reason to do so would be hindsight reconstruction based on the claims of the present application, as explained above. This is clearly improper.

Yet another reason that one skilled in the art would not be motivated to rely upon Grothe is that Grothe does not disclose a display device as in the claimed method and Arai. Hence, one skilled in the art would have no motivation to even look at Grothe.

Therefore, as there is no proper motivation or reason to combine Arai and Grothe, the combination of these two references is improper, and the rejection based thereon is improper. Hence, a prima facie case of obviousness has not been established.

ii. The Combination of Monk and Arai Is Improper

While Monk teaches that, in a process where some wafers are coated from an evaporation source, it is known that "either the source of the samples must be moved relative to each other during

treatment" (emphasis added), Monk discloses a face-up method in which film formation is performed with the wafer surface, onto which a film is to be formed, facing upward. See e.g. Fig. 4 in Monk. Monk does not disclose or suggest a face-down method.

Further, Monk does not disclose a display device or method for forming a display device. The Examiner disregards and simply dismisses this fact in his analysis. Appellants have questioned the Examiner as to what would be one skilled in the art's motivation to look at Monk when it is directed to different technology. The Examiner has failed to provide an answer to this question.

In fact, there would have been no motivation for one skilled in the art to combine Arai and Monk to try to arrive at the claimed invention. Further, no explanation is provided for how one skilled in the art would incorporate Monk into Arai. The only way these two references could be combined is through improper hindsight reconstruction.

Therefore, the combination of Monk and Arai is improper, and the rejection based thereon is improper.

b. Evidence Of Nonobviousness Of Claimed Invention

The nonobviousness of the claimed invention is evidenced by the fact that others did not begin to use ideas similar to the present invention until after Applicants' invention. For example, the Examiner has not found a single prior reference showing the claimed invention or anything remotely similar to it. Instead, he has to attempted to combine four or more references to try to come close to the claimed invention. As Appellants show above, the Examiner's attempt is improper.

After Applicants' invention, however, references, such as US patent publication 2002/0076847 (Yamada et al.), US patent publication 2002/0179013 (Kido et al), and Van Slyke et

al. "Linear Source Deposition of Organic Layers for Full-Color OLED", SID 02 Digest, p. 886-889 (2002), show ideas similar to the present invention. Each of these references are dated after the date of the present application. Each of these references was made of record in this application with the information disclosure statement of May 22, 2006 and considered by the Examiner with the Final Rejection of August 10, 2006. If the present invention was obvious, these ideas would have surfaced prior to Applicants' invention. This is evidence of the non-obviousness of the claimed invention and rebuts any argument by the Examiner.

Accordingly, it is respectfully submitted that the method of independent Claim 20 and those claims dependent thereon is nonobvious.

c. Conclusion

Accordingly, for at least the above-stated reasons, the rejection of independent Claim 20 is improper as the motivation for the combination of references is not valid or supportable, and one skilled in the art would not combine these references. Instead, the combination must be based on improper hindsight reconstruction. Accordingly, a prima facie case of obviousness has not been proved by the Examiner.

Further, independent Claim 20 and those claims dependent thereon are not obvious in view of these references.

Therefore, these claims are patentable over these references, and it is respectfully requested that this rejection be reversed or withdrawn.

3. THE OTHER REJECTIONS OF THE CLAIMS ARE SIMILARLY IMPROPER

Claims 37, 43, 48, 53, 64, 75 and 157

The Examiner also rejects Claims 37, 43, 48, 53, 64, 75 and 157 under 35 USC §103 as being unpatentable over Arai et al. in view of Bennett (US 2,435,997) and Grothe et al. and Nagayama et al. This rejection is also respectfully traversed.

In the Final Rejection, the Examiner combines Arai, Grothe and Nagayama in the same manner discussed above, and further contends that it would have been obvious to one of ordinary skill in the art to modify the method of Arai so as to move the evaporation source relative to the substrate, as allegedly taught by Bennett.

For at least the reasons discussed above, independent Claim 37 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claims 38, 48, 56, 65, 76, 153 and 158

The Examiner also rejects Claims 38, 48, 56, 65, 76, 153 and 158 under 35 USC §103 as being unpatentable over Arai et al. in view of Bennett, Grothe et al., Nagayama et al. and Monk. This rejection is also respectfully traversed.

In the Final Rejection, the Examiner combines Arai, Grothe and Nagayama in the same manner discussed above, and further contends that it would have been obvious to further modify the method of Arai with the alleged teachings of Bennett and Monk.

For at least the reasons discussed above, independent Claim 38 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is

respectfully requested that this rejection be reversed or withdrawn.

Claims 39, 48, 53, 57, 66, 77 and 159

The Examiner also rejects Claims 39, 48, 53, 57, 66, 77 and 159 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al (US 4,627,989), Bennett, and Yamamoto et al. (JP 11-61386; US 6,179,923 as English equivalent). This rejection is also respectfully traversed.

In the Final Rejection, the Examiner asserts Arai and Nagayama in the same manner discussed above, and further contends that it would have been obvious to one of ordinary skill in the art to modify the method of Arai with the alleged teachings of Feuerstein, Bennett and Yamamoto

For at least the reasons discussed above, independent Claim 39 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claims 40, 48, 58, 67, 78, 154 and 160

The Examiner also rejects Claims 40, 48, 58, 67, 78, 154 and 160 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al. or in the alternative over Arai et al. in view of Nagayama et al., Feuerstein et al., Bennett, Monk, and Yamamoto et al. This rejection is also respectfully traversed.

In the Final Rejection, the Examiner combines the references in the same manner discussed above, contends that it would have been obvious to combine these references to arrive at the claimed invention, and contends that undisclosed features would be inherent in the references.

For at least the reasons discussed above, independent Claim 40 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claim 49

The Examiner also rejects Claim 49 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. and further in view of Spitzer et al. (US 5,258,325). This rejection is also respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 54, 68, 71, 79 and 161

The Examiner also rejects Claims 54, 68, 71, 79 and 161 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al. and Yamamoto et al. This rejection is also respectfully traversed.

In the Final Rejection, the Examiner combines the references in the same manner discussed above, contends that it would have been obvious to combine the references to arrive at the claimed invention, and contends that the undisclosed features would be inherent in the references or obvious.

For at least the reasons discussed above, independent Claim 54 and those claims dependent thereon are patentable over these cited references and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claims 55, 69, 72, 80, 155 and 162

The Examiner also rejects Claims 55, 69, 72, 80, 155 and 162 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al., Monk, and Yamamoto et al. This rejection is also respectfully traversed.

In the Final Rejection, the Examiner combines the references in the same manner discussed above, contends that it would have been obvious to combine these references to arrive at the claimed invention, and contends that undisclosed features would be inherent in the references.

For at least the above-stated reasons, independent Claim 55 and those claims dependent thereon are patentable over these cited references and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claim 59

The Examiner also rejects Claim 59 under 35 USC §103 as being unpatentable over Arai et al., in view of Nagayama et al., Bennett and Grothe et al; further in view of Spitzer et al. This rejection is also respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claim 60

The Examiner also rejects Claim 60 under 35 USC §103 as being unpatentable over Arai et

al., in view of Nagayama et al., Bennett, Grothe et al. and Monk, further in view of Spitzer et al. This rejection is also respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claim 61

The Examiner also rejects Claim 61 under 35 USC §103 as being unpatentable over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al., further in view of Spitzer et al. This rejection is also respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claim 62

The Examiner also rejects Claim 62 under 35 USC §103 as being unpatentable over Arai et al., in view of Nagayama et al., Feurestein et al., Bennett and Yamamoto et al., or in the alternative over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk and Yamamoto et al., further in view of Spitzer et al. This rejection is respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claim 73

The Examiner also rejects Claim 73 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al., further in view of Mizutani et al. (US 6,326,726). This rejection is respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 81-88, 92-100, 141-144, 163, 164, 166-168 and 169-176

The Examiner also rejects Claims 81-88, 92-100, 141-144, 163, 164, 166-168 and 169-176 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. This rejection is respectfully traversed.

In the Final Rejection, the Examiner combines the references in the same manner discussed above, contends that it would have been obvious to combine these references to arrive at the claimed invention, and contends that undisclosed features would be inherent in the references.

For at least the above-stated reasons, independent Claims 81, 85, 92, 95 and 98 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claims 89-91 and 165

The Examiner also rejects Claims 89-91 and 165 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. This rejection is respectfully

traversed.

In the Final Rejection, the Examiner combines the references in the same manner discussed above, contends that it would have been obvious to combine these references to arrive at the claimed invention, and contends that undisclosed features would be inherent in the references.

For at least the above-stated reasons, independent Claim 89 and those claims dependent thereon are patentable over these cited references, and the rejection is improper. Accordingly, it is respectfully requested that this rejection be reversed or withdrawn.

Claim 101

The Examiner also rejects Claim 10 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al., further in view of Spitzer. This rejection is respectfully traversed.

This claim is a dependent claim. Therefore, for at least the reasons discussed above for the independent claim, this claim would also be patentable. Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 102-104

The Examiner also rejects Claims 102-104 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk, Nagayama et al. and further in view of Bertelsen (US 3,110,620). This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable.

Further, as the Examiner admits, this feature, that a lower surface of the substrate is provided with a transparent conducting film, is not disclosed in any of the cited references.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 105-107

The Examiner also rejects Claims 105-107 under 35 USC §103 as being unpatentable over Arai et al. in view of Bennett, Grothe et al., and Nagayama et al. and further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 108-110

The Examiner also rejects Claims 108-110 under 35 USC §103 as being unpatentable over Arai et al. in view of Bennett, Grothe et al., Nagayama et al., and Monk and further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 111-113

The Examiner also rejects Claims 111-113 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Feurestein et al., Bennett, and Yamamoto et al. and further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 114-116

The Examiner also rejects Claims 114-116 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Feuerstein et al., Bennett, and Yamamoto et al. or in the alternative, over Arai et al., in view of Nagayama et al., Feuerstein et al., Bennett, Monk and Yamamoto et al. further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 117-119

The Examiner also rejects Claims 117-119 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al. and Yamamoto et al. further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 120-122

The Examiner also rejects Claims 120-122 under 35 USC §103 as being unpatentable over Arai et al. in view of Nagayama et al., Bennett, Grothe et al., Monk and Yamamoto et al. further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 123-128 and 132-138

The Examiner also rejects Claims 123-128 and 132-138 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

Claims 129-131

The Examiner also rejects Claims 129-131 under 35 USC §103 as being unpatentable over Arai et al. in view of Grothe et al., Monk and Nagayama et al. further in view of Bertelsen. This rejection is respectfully traversed.

These claims are dependent claims. Therefore, for at least the reasons discussed above for the independent claims, these claims would also be patentable. Further, for the reasons explained above for Claims 102-104, these claims are also nonobvious.

Accordingly, it is requested that this rejection be reversed or withdrawn.

C. CONCLUSION

For at least the reasons stated above, Appellants earnestly and respectfully submit that the Examiner has failed to present a prima facie case of obviousness as the Examiner's alleged motivation to combine references is not valid, and the combination of references and rejections are based on improper hindsight reconstruction. Further, the claims would not have been obvious in view of the cited references.

Hence, the rejection of the claims should be reversed, and the claims allowed.

Accordingly, Appellants request that this Appeal be sustained in all respects, and that all rejections in the Final Rejection be reversed.

Respectfully submitted,

/Mark J. Murphy/
Mark J. Murphy
Registration No. 34,225

COOK, ALEX, McFARRON, MANZO,
CUMMINGS & MEHLER, LTD.
200 West Adams Street, Suite 2850
Chicago, Illinois 60606
Customer No. 26568

February 6, 2007

viii. CLAIMS APPENDIX

In accordance with 37 CFR 41.37(c)(1)(viii), the text of the claims on appeal is as follows:

20. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in a first evaporation chamber;

providing a second evaporation source in a second evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the first evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material in order that a same portion of the substrate is coated with the first material at least twice;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material;

evaporating a second material from said second evaporation source to deposit said second material over the substrate wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material.

21. The method according to claim 20 further comprising a step of cleaning an inside of the first and second evaporation chambers, respectively.

22. The method according to claim 20 wherein said first and second evaporation chambers are connected to each other through a conveyor chamber.

37. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material;

evaporating a second material from said second evaporation source to deposit said second material over the substrate in the evaporation chamber; and

repeatedly moving the relative position of the second evaporation source with respect

to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice.

38. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material in order that a same portion of the substrate is coated with the first material at least twice;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material;

evaporating a second material from said second evaporation source to deposit said second material over the substrate in the evaporation chamber; and

repeatedly moving the relative position of the second evaporation source with respect

to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate.

39. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber wherein the first evaporation source comprises a plurality of first evaporation cells arranged along a first direction;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein the second evaporation source comprises a plurality of second evaporation cells;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material so that the plurality of second evaporation cells are arranged in the first direction;

evaporating a second material from said second evaporation source to deposit said second material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect

to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber.

40. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber wherein the first evaporation source comprises a plurality of first evaporation cells arranged along a first direction;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein the second evaporation source comprises a plurality of second evaporation cells;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along a second direction during the step of evaporating the first material in order that a same portion of the substrate is coated with the first material at least twice;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material so that the plurality of second evaporation cells are arranged in the first direction;

evaporating a second material from said second evaporation source to deposit said

second material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate.

43. The method according to claim 37 wherein said second direction is orthogonal to the first direction.

44. The method according to claim 20 wherein the relative position of the first evaporation source is moved with respect to the substrate in a direction orthogonal to an elongation direction of the first evaporation source.

45. The method according to claim 20 wherein the relative position of the second evaporation source is moved with respect to the substrate in a direction orthogonal to an elongation direction of the second evaporation source.

48. The method according to any one of claims 20 and 37-40 wherein at least one of the first and second materials comprises an organic material.

49. The method according to claim 20 wherein said display device is an active matrix electroluminescence display device.

53. The method according to any one of claims 37 and 39 wherein the relative position of the first evaporation source is repeatedly moved with respect to the substrate so that a same portion of the substrate is coated with the first material at least twice.

54. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material in order that a same portion of the substrate is coated with the first material at least twice;

transferring the second evaporation source from the second chamber into the

evaporation chamber after evaporating the first material;

evaporating a second material from said second evaporation source to deposit said second material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber.

55. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in an evaporation chamber;

providing a second evaporation source in a second chamber connected to the evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit said first material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material in order that a same portion of the substrate is coated with the first material at least twice;

transferring the second evaporation source from the second chamber into the evaporation chamber after evaporating the first material;

evaporating a second material from said second evaporation source to deposit said second material over the substrate in the evaporation chamber;

repeatedly moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material in order that a same portion of the substrate is coated with the second material at least twice; and

cleaning an inside of the evaporation chamber,

wherein each of the first and second evaporation sources is longer than at least one edge of the substrate.

56. The method according to claim 38 wherein said second direction is orthogonal to the first direction.

57. The method according to claim 39 wherein said second direction is orthogonal to the first direction.

58. The method according to claim 40 wherein said second direction is orthogonal to the first direction.

59. The method according to claim 37 wherein said display device is an active matrix electroluminescence display device.

60. The method according to claim 38 wherein said display device is an active matrix electroluminescence display device.

61. The method according to claim 39 wherein said display device is an active matrix electroluminescence display device.

62. The method according to claim 40 wherein said display device is an active matrix electroluminescence display device.

63. The method according to claim 20 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

64. The method according to claim 37 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

65. The method according to claim 38 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

66. The method according to claim 39 wherein uniformity of the distribution of film

thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

67. The method according to claim 40 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

68. The method according to claim 54 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

69. The method according to claim 55 wherein uniformity of the distribution of film thickness of a thin film in a rectangular shape, elliptical shape, or a linear shape region is maintained by using the first evaporation source during the evaporation.

70. The method according to claim 20 wherein said first and second evaporation chambers are connected with each other through at least one gate.

71. The method according to claim 54 wherein at least one of the first and second materials comprises an organic material.

72. The method according to claim 55 wherein at least one of the first and second materials

comprises an organic material.

73. The method according to claim 20 wherein the mask fixed to a mask holder approaches the substrate by a magnet field.

74. The method according to claim 20 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

75. The method according to claim 37 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

76. The method according to claim 38 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

77. The method according to claim 39 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

78. The method according to claim 40 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

79. The method according to claim 54 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

80. The method according to claim 55 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

81. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in a first evaporation chamber;

providing a second evaporation source in a second evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the first evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit a hole injecting layer over the substrate wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material in order that a same portion of the substrate is coated with the material at least twice;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material; and

evaporating a second material from said second evaporation source to deposit a light emitting layer over the hole injecting layer wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material in the second evaporation chamber.

82. The method according to claim 81 wherein the hole injecting layer comprises an organic material.

83. The method according to claim 81 wherein the light emitting layer comprises an organic material.

84. The method according to claim 81 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

85. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source in a first evaporation chamber;

providing a second evaporation source in a second evaporation chamber wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in the first direction than in the second direction;

disposing a substrate in the first evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from said first evaporation source to deposit a hole injecting layer over the substrate wherein the relative position of the substrate is repeatedly moved with respect to the first evaporation source during the evaporation of the first material in order that a same portion of the substrate is coated with the material at least twice;

transferring the substrate from the first evaporation chamber into the second evaporation chamber after the deposition of the first material;

evaporating a second material from said second evaporation source to deposit a light emitting layer over the hole injecting layer wherein the relative position of the substrate is moved with respect to the second evaporation source during the evaporation of the second material;

forming a conducting film by evaporation over the light emitting layer; and

sealing the light emitting layer by sealing material without exposure to the atmosphere.

86. The method according to claim 85 wherein the hole injecting layer comprises an organic material.

87. The method according to claim 85 wherein the light emitting layer comprises an organic material.

88. The method according to claim 85 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

89. A method of manufacturing an electroluminescence display device comprising:

providing a first evaporation source and a second evaporation source in an evaporation chamber, wherein each of the first and second evaporation sources has a first direction and a second direction different from each other, each of the first and second evaporation sources being longer in

the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the first evaporation source;

evaporating a first material from the first evaporation source to deposit said first material over a first pixel portion of the substrate in the evaporation chamber;

moving the relative position of the first evaporation source with respect to the substrate along the second direction during the step of evaporating the first material;

moving the mask by one pixel portion;

evaporating a second material from said second evaporation source to deposit said second material over a second pixel portion in the evaporation chamber; and

moving the relative position of the second evaporation source with respect to the substrate along the second direction during the step of evaporating the second material.

90. The method according to claim 89 wherein at least one of the first and second materials comprises an organic material.

91. The method according to claim 89 wherein each of the first and second evaporation sources has a length exceeding 300 mm along the first direction.

92. A method of manufacturing an electroluminescence display device comprising:

providing an evaporation source in an evaporation chamber, wherein the evaporation

source has a first direction and a second direction different from each other, the evaporation source being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the evaporation source; and

evaporating a material from the evaporation source to form a hole injecting layer over the substrate wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material.

93. The method according to claim 92 wherein the hole injecting layer comprises an organic material.

94. The method according to claim 92 wherein the evaporation source has a length exceeding 300 mm along the first direction.

95. A method of manufacturing an electroluminescence display device comprising:

providing an evaporation source in an evaporation chamber, wherein the evaporation source has a first direction and a second direction different from each other, the evaporation source being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the evaporation source;

evaporating a material from said the evaporation source to form a light emitting layer over the substrate wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material.

96. The method according to claim 95 wherein the light emitting layer comprises an organic material.

97. The method according to claim 95 wherein the evaporation source has a length exceeding 300 mm along the first direction.

98. A method of manufacturing an electroluminescence display device comprising:

providing an evaporation source in an evaporation chamber, wherein the evaporation source has a first direction and a second direction different from each other, the evaporation source being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

evaporating a material from said evaporation source to form a light emitting layer comprising said material over the substrate wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material.

99. The method according to claim 98, further comprising steps of:

fixing a mask to the substrate wherein the mask is located between the substrate and the evaporation source.

100. The method according to claim 98 wherein the evaporation source has a length exceeding 300 mm along the first direction.

101. The method according to claim 98 wherein said electroluminescence display device is an active matrix electroluminescence display device.

102. A method according to claim 20, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

103. A method according to claim 20, wherein a lower surface of the substrate is provided with thin films.

104. A method according to claim 20, wherein a lower surface of the substrate is provided with a transparent conducting film.

105. A method according to claim 37, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

106. A method according to claim 37, wherein a lower surface of the substrate is provided with thin films.

107. A method according to claim 37, wherein a lower surface of the substrate is provided with a transparent conducting film.

108. A method according to claim 38, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

109. A method according to claim 38, wherein a lower surface of the substrate is provided with thin films.

110. A method according to claim 38, wherein a lower surface of the substrate is provided with a transparent conducting film.

111. A method according to claim 39, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

112. A method according to claim 39, wherein a lower surface of the substrate is provided with thin films.

113. A method according to claim 39, wherein a lower surface of the substrate is provided with a transparent conducting film.

114. A method according to claim 40, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

115. A method according to claim 40, wherein a lower surface of the substrate is provided with thin films.

116. A method according to claim 40, a lower surface of the substrate is provided with a transparent conducting film.

117. A method according to claim 54, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

118. A method according to claim 54, wherein a lower surface of the substrate is provided with thin films.

119. A method according to claim 54, wherein a lower surface of the substrate is provided with a transparent conducting film.

120. A method according to claim 55, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

121. A method according to claim 55, wherein a lower surface of the substrate is provided with thin films.

122. A method according to claim 55, wherein a lower surface of the substrate is provided with a transparent conducting film.

123. A method according to claim 81, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

124. A method according to claim 81, wherein a lower surface of the substrate is provided with thin films.

125. A method according to claim 81, wherein a lower surface of the substrate is provided with a transparent conducting film.

126. A method according to claim 85, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

127. A method according to claim 85, wherein a lower surface of the substrate is provided with thin films.

128. A method according to claim 85, a lower surface of the substrate is provided with a transparent conducting film.

129. A method according to claim 89, wherein the substrate is located above the first evaporation source,

wherein the first material is formed on a lower surface of the substrate.

130. A method according to claim 89, wherein a lower surface of the substrate is provided with thin films.

131. A method according to claim 89, wherein a lower surface of the substrate is provided with a transparent conducting film.

132. A method according to claim 92, wherein the substrate is located above the evaporation source,

wherein the first material is formed on a lower surface of the substrate.

133. A method according to claim 92, wherein a lower surface of the substrate is provided with thin films.

134. A method according to claim 92, wherein a lower surface of the substrate is provided with a transparent conducting film.

135. A method according to claim 95, wherein the substrate is located above the evaporation source,

wherein the first material is formed on a lower surface of the substrate.

136. A method according to claim 95, wherein a lower surface of the substrate is provided with thin films.

137. A method according to claim 95, wherein a lower surface of the substrate is provided with a transparent conducting film.

138. A method according to claim 98, wherein the substrate is located above the evaporation source,

wherein the material is formed on a lower surface of the substrate.

139. A method according to claim 98, wherein a lower surface of the substrate is provided with thin films.

140. A method according to claim 98, wherein a lower surface of the substrate is provided with a transparent conducting film.

141. A method according to claim 95, wherein said material is organic.

142. A method according to claim 95, wherein said material is inorganic.

143. A method according to claim 98, wherein said material is organic.

144. A method according to claim 98, wherein said material is inorganic.

145. A method according to claim 39, wherein a gap between said first evaporation cells has a distance a and a distance between said first evaporation source and said mask is 2a to 100a.

146. A method according to claim 145, wherein said distance between said first evaporation source and said mask is 5a to 50a.

147. A method according to claim 39, wherein a gap between said second evaporation cells has a distance a and a distance between said second evaporation source and said mask is 2a to 100a.

148. A method according to claim 147, wherein said distance between said second evaporation source and said mask is 5a to 50a.

149. A method according to claim 40, wherein a gap between said first evaporation cells has a distance a and a distance between said first evaporation source and said mask is 2a to 100a.

150. A method according to claim 149, wherein said distance between said first evaporation source and said mask is 5a to 50a.

151. A method according to claim 40, wherein a gap between said second evaporation cells has a distance a and a distance between said second evaporation source and said mask is 2a to 100a.

152. A method according to claim 151, wherein said distance between said second evaporation source and said mask is 5a to 50a.

153. A method according to claim 38, wherein during evaporation each of the first and second evaporation sources moves from one end of the substrate to the other end.

154. A method according to claim 40, wherein during evaporation each of the first and second evaporation sources moves from one end of the substrate to the other end.

155. A method according to claim 55, wherein during evaporation each of the first and second evaporation sources moves from one end of the substrate to the other end.

156. A method according to claim 20, wherein said display device is a passive matrix electroluminescence display device.

157. A method according to claim 37, wherein said display device is a passive matrix

electroluminescence display device.

158. A method according to claim 38, wherein said display device is a passive matrix electroluminescence display device.

159. A method according to claim 39, wherein said display device is a passive matrix electroluminescence display device.

160. A method according to claim 40, wherein said display device is a passive matrix electroluminescence display device.

161. A method according to claim 54, wherein said display device is a passive matrix electroluminescence display device.

162. A method according to claim 55, wherein said display device is a passive matrix electroluminescence display device.

163. A method according to claim 81, wherein said display device is a passive matrix electroluminescence display device.

164. A method according to claim 85, wherein said display device is a passive matrix electroluminescence display device.

165. A method according to claim 89, wherein said display device is a passive matrix electroluminescence display device.

166. A method according to claim 92, wherein said display device is a passive matrix electroluminescence display device.

167. A method according to claim 95, wherein said display device is a passive matrix electroluminescence display device.

168. A method according to claim 98, wherein said display device is a passive matrix electroluminescence display device.

169. A method of manufacturing an electroluminescence display device comprising:

providing an evaporation source in an evaporation chamber, wherein the evaporation source has a first direction and a second direction different from each other, the evaporation source being longer in the first direction than in the second direction;

disposing a substrate in the evaporation chamber;

fixing a mask to the substrate wherein the mask is located between the substrate and the evaporation source; and

evaporating a material from said the evaporation source to form a light emitting layer over the substrate wherein the relative position of the substrate is moved with respect to the evaporation source during the evaporation of the material,

wherein the mask has at least a rectangular shaped open portion, and

wherein a longitudinal direction of open portion is perpendicular to the first direction of the evaporation source.

170. The method according to claim 169, wherein said second direction is orthogonal to the first direction.

171. The method according to claim 169 wherein said electroluminescence display device is a color display,

wherein the substrate is located above the evaporation source,

wherein a lower surface of the substrate is provided with thin films,

wherein thin films of materials for emitting different colors are formed for each pixel.

172. The method according to claim 169 wherein each of the evaporation sources has a length exceeding 300 mm along the first direction.

173. A method according to claim 169, wherein said material is organic.

174. A method according to claim 169, wherein said material is inorganic.

175. The method according to claim 169 wherein said electroluminescence display device is a passive matrix electroluminescence display device.

176. The method according to claim 169 wherein said electroluminescence display device is an active matrix electroluminescence display device.

ix. EVIDENCE APPENDIX

1. U.S. patent publication number 2002/0076847 (Yamada et al.).

2. U.S. patent publication number 2002/0179013 (Kido et al.).

3. Van Slyke et al. "Linear Source Deposition of Organic Layers for Full-Color OLED", SID 02 Digest, p. 886-889 (2002).

These references were made of record in the information disclosure statement of May 26, 2006 and were considered and entered by the Examiner with the Final Rejection of August 10, 2006.

x. RELATED PROCEEDINGS APPENDIX

None

US 20020076847A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2002/0076847 A1**

(43) **Pub. Date: Jun. 20, 2002**

Yamada et al.

(54) **METHOD OF ATTACHING LAYER MATERIAL AND FORMING LAYER IN PREDETERMINED PATTERN ON SUBSTRATE USING MASK**

(76) Inventors: **Tsutomu Yamada**, Motogu-gun (JP); **Kiyoshi Yoneda**, Motosu-gun (JP)

Correspondence Address:
CANTOR COLBURN, LLP
55 GRIFFIN ROAD SOUTH
BLOOMFIELD, CT 06002

(21) Appl. No.: **09/966,692**

(22) Filed: **Sep. 28, 2001**

(30) **Foreign Application Priority Data**

Sep. 28, 2000 (JP) 2000-296582
Sep. 20, 2001 (JP) 2001-287328

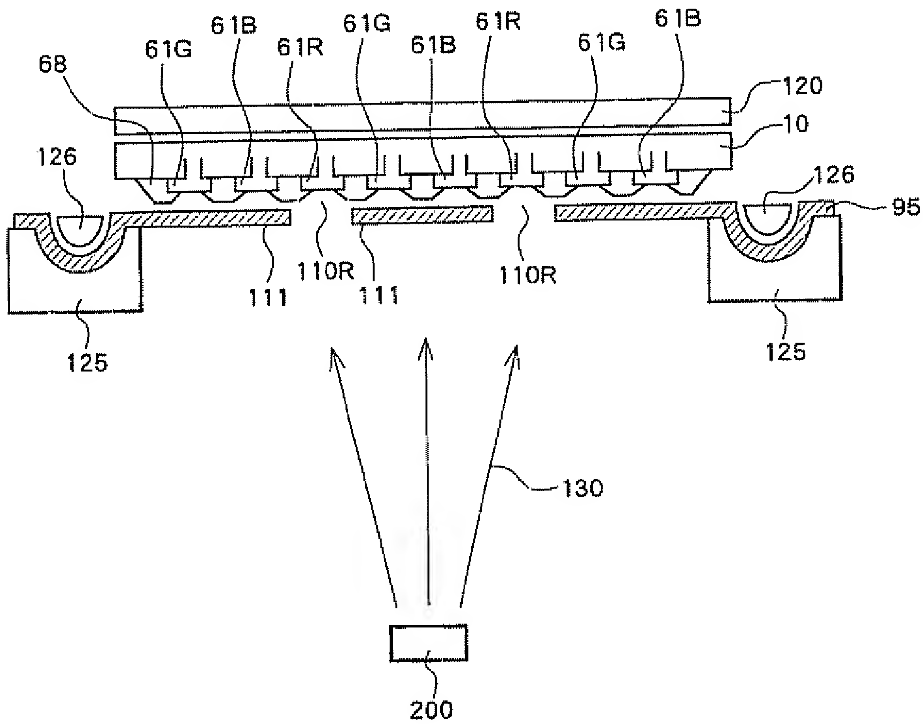
Publication Classification

(51) **Int. Cl.^{7}** **H01L 21/00**

(52) **U.S. Cl.** **438/34**; 438/944

(57) **ABSTRACT**

Upon formation of a layer such as an emissive layer of an organic EL element by attaching an emissive material onto a substrate (**10**), an evaporation mask (**100**) including an opening (**110**) corresponding to the layer formed to have a plurality of individual patterns and having an area, for example, smaller than the substrate is disposed between the substrate (**10**) and a material source (**200**) A relative position between the mask (**100**) and the material source (**200**), and the substrate (**10**) is slid by a predetermined pitch corresponding to the size of a pixel of the substrate (**10**), thereby forming a material layer (such as the emissive layer **64**) in a predetermined region of the substrate. As a result, the material layer can be formed on the substrate through, for example, evaporation with a high accuracy



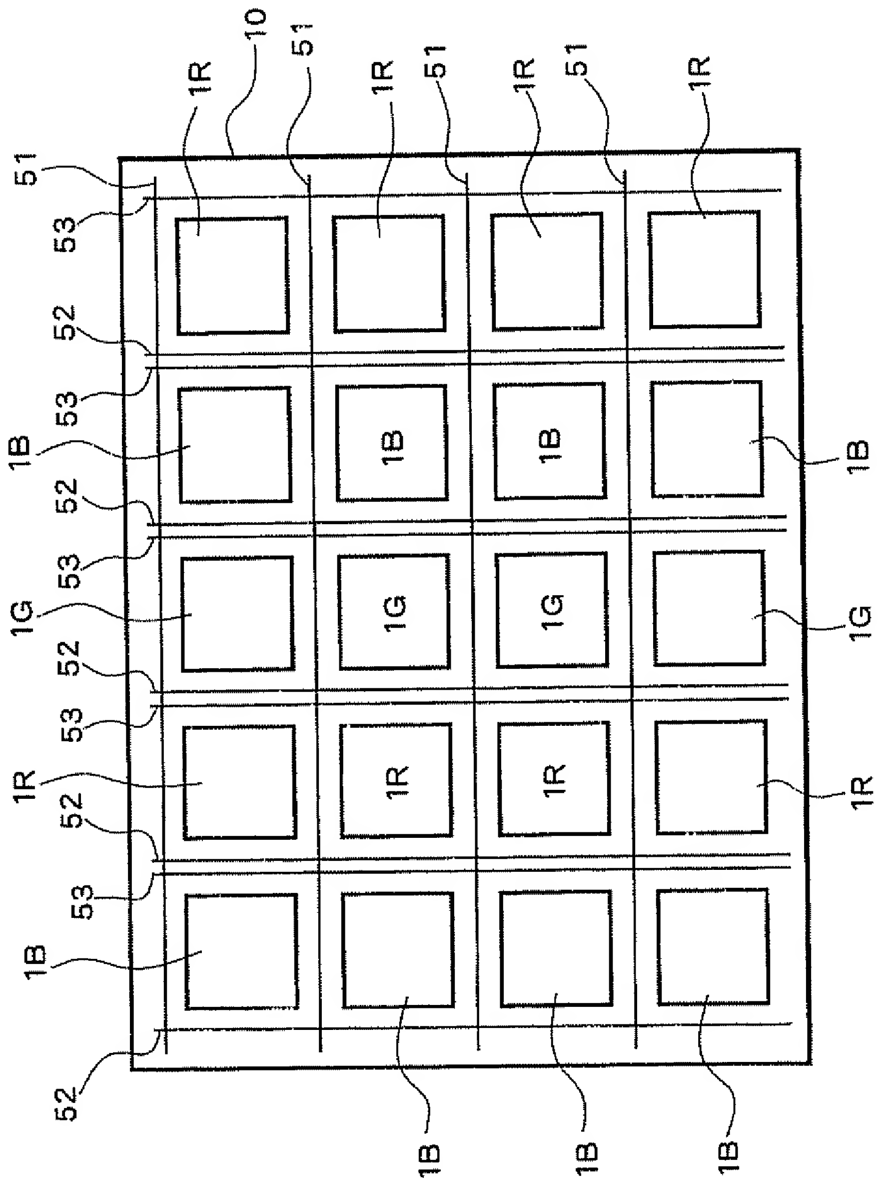

10
51
51
51
51
1R
1R
1R
1R
53
52
53
1B
1B
1B
1B
52
53
1G
1G
1G
1G
52
53
1R
1R
1R
1R
52
53
1B
52
1B
1B
1B

Fig. 1

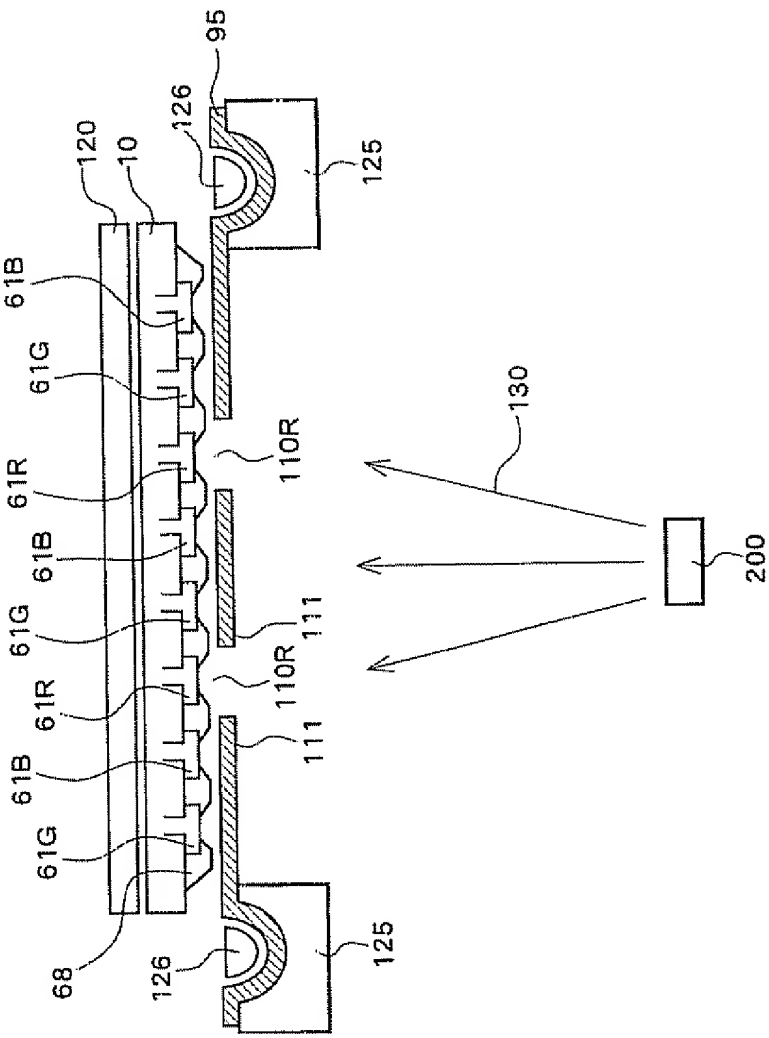

95
126
120
10
125
61B
61G
61R
61B
61G
61R
61B
61G
68
126
125
110R
130
111
110R
111
200

Fig. 2

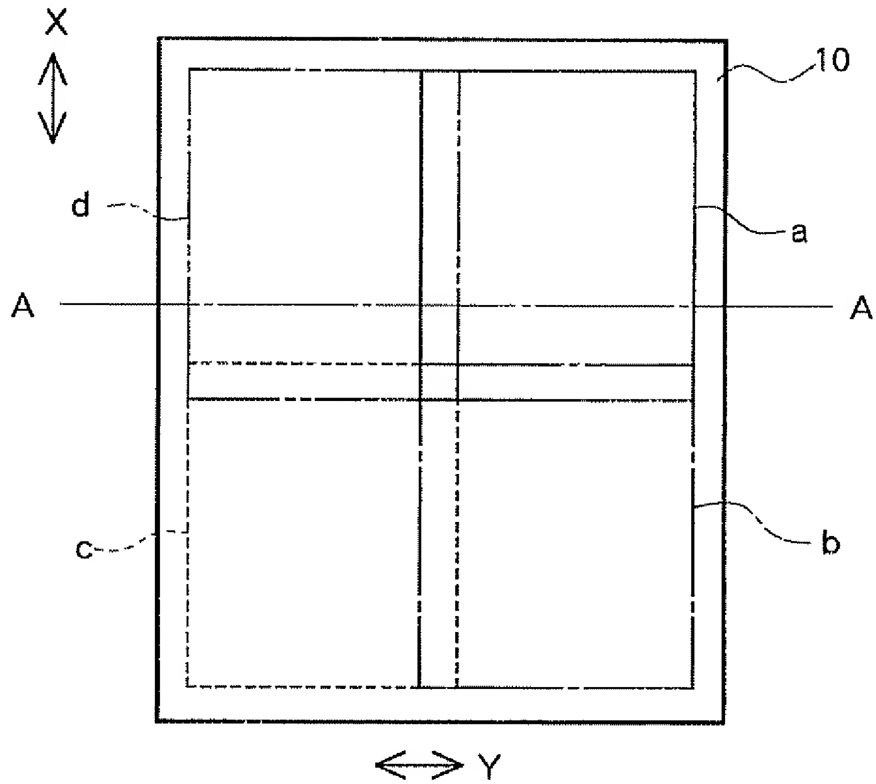


Fig. 3

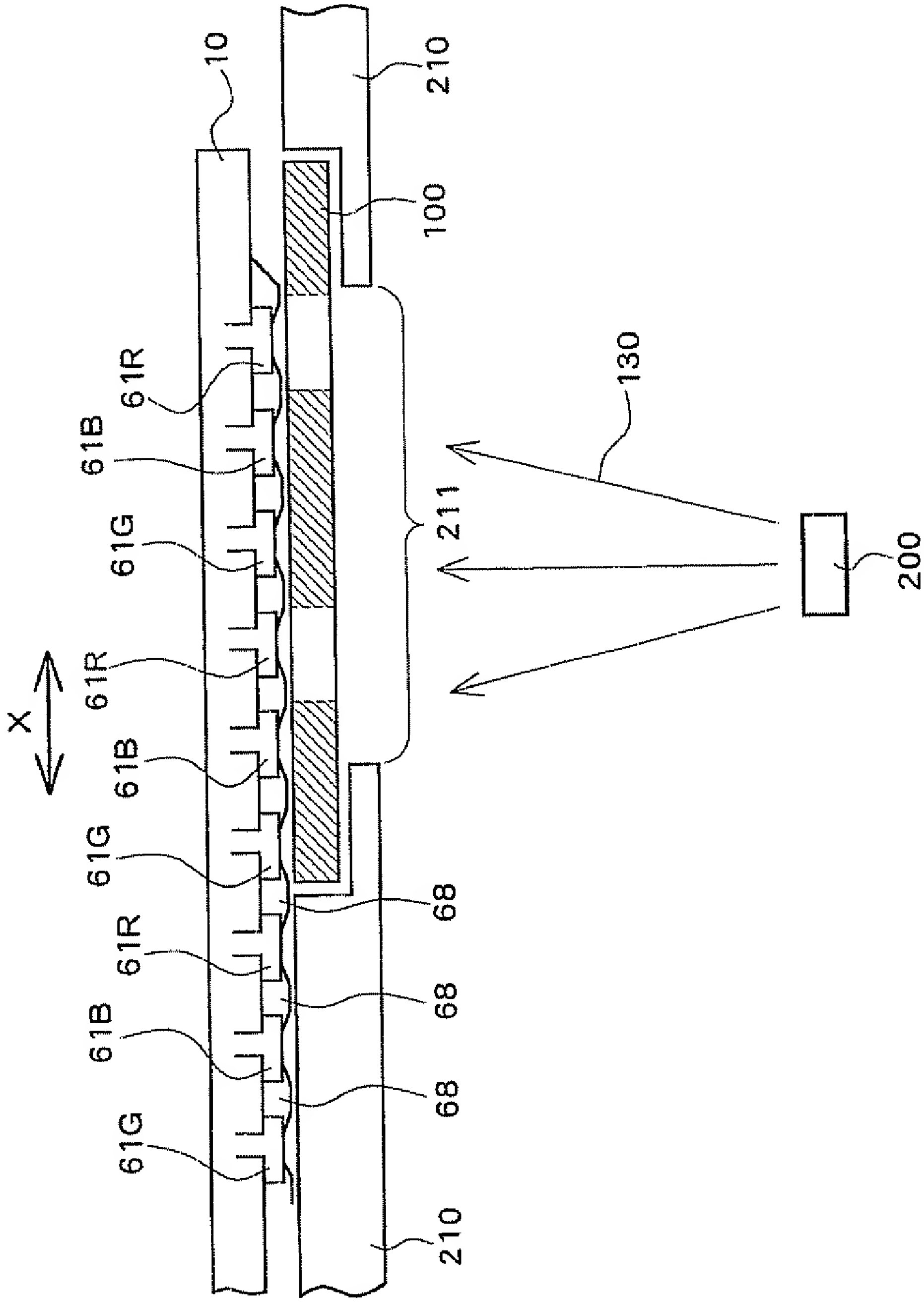

10
210
100
130
211
200
X
61R
61B
61G
61R
61B
61G
61R
61B
61G
68
68
68
210

Fig. 4

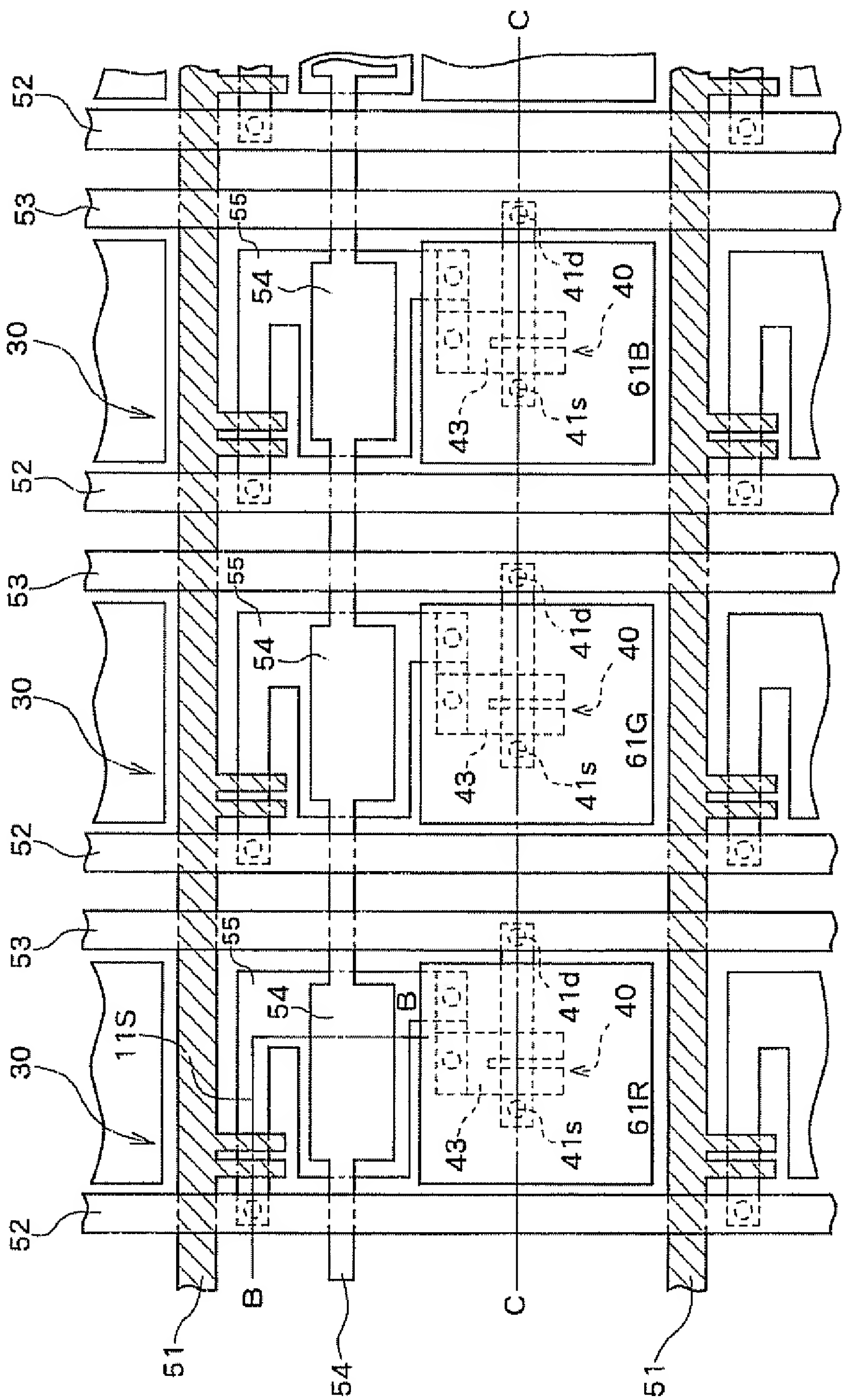


Fig. 5

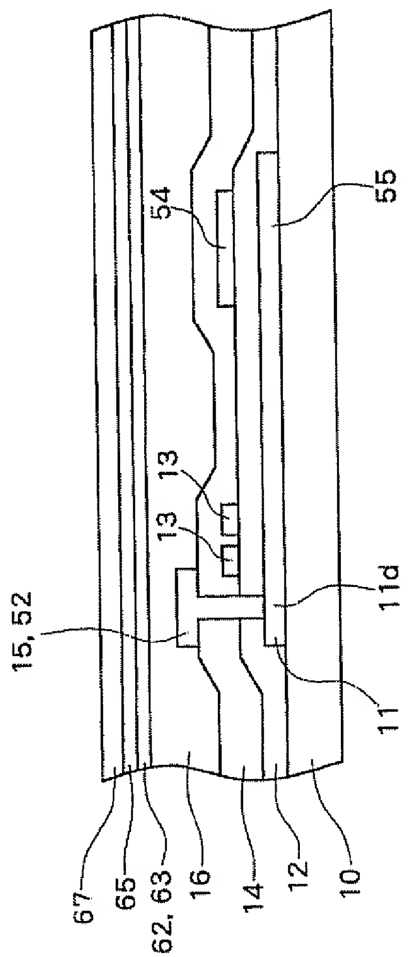

15, 52
13
13
54
55
11d
11
67
65
62, 63
16
14
12
10

Fig. 6A

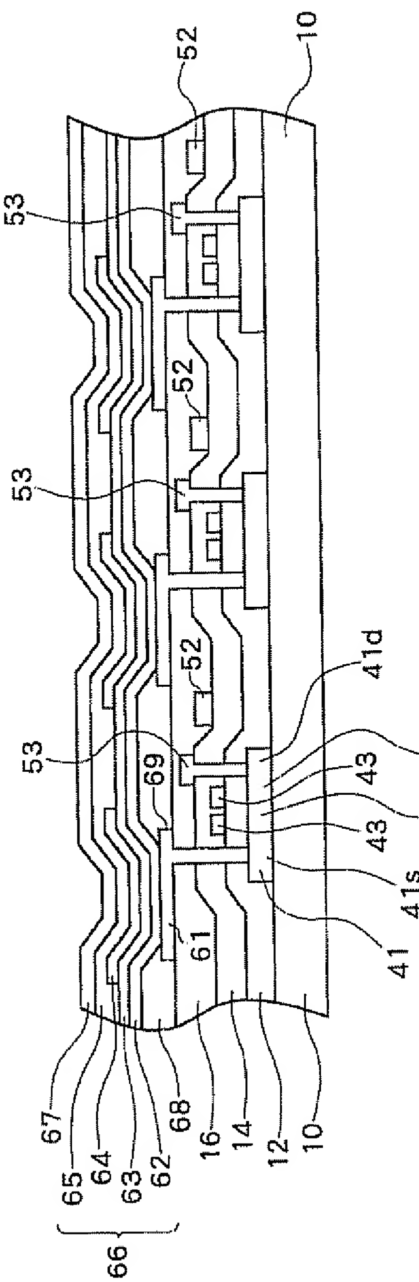

52
10
53
52
53
52
41d
53
69
69
43c
43
43c
43
61
41s
41
67
65
64
63
62
68
16
14
12
10
66

Fig. 6B

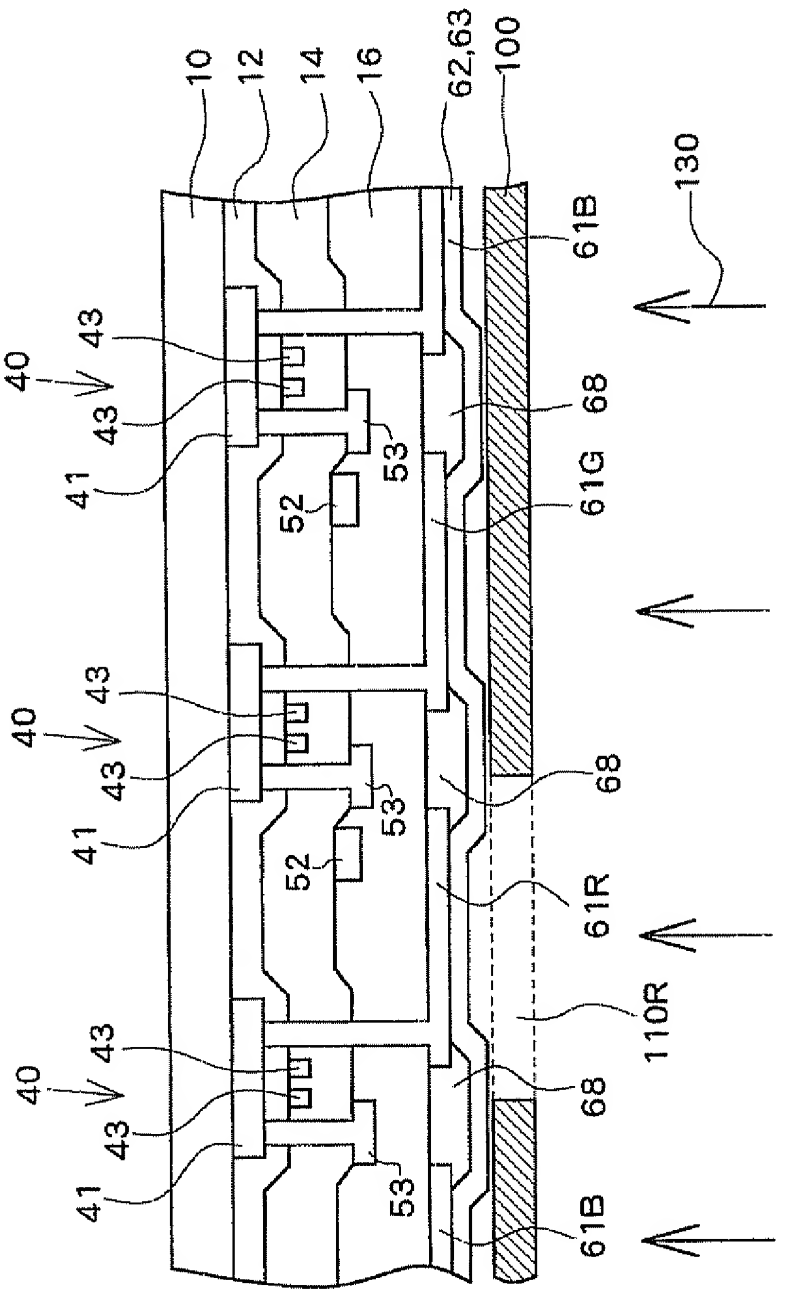

10
12
14
16
62,63
100
130
61B
43
40
43
68
41
53
61G
52
43
40
43
68
41
53
52
61R
110R
43
40
43
68
41
53
61B

Fig. 7

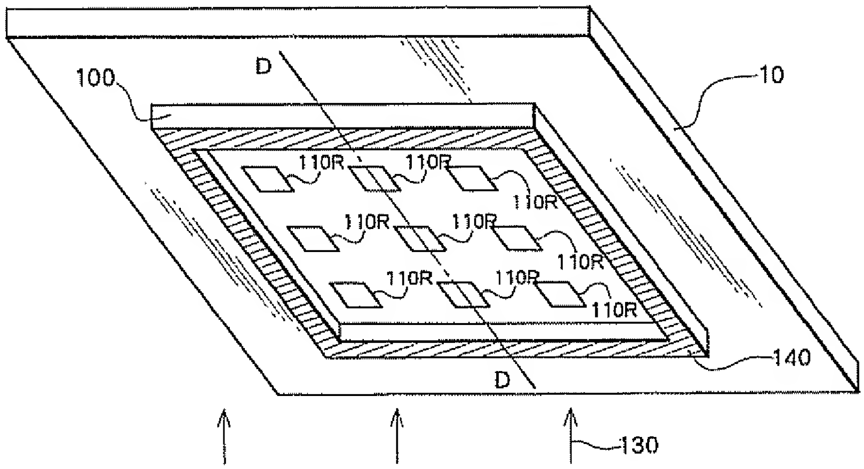

D
100
10
110R
110R
110R
110R
110R
110R
110R
110R
110R
140
D
130

Fig. 8A

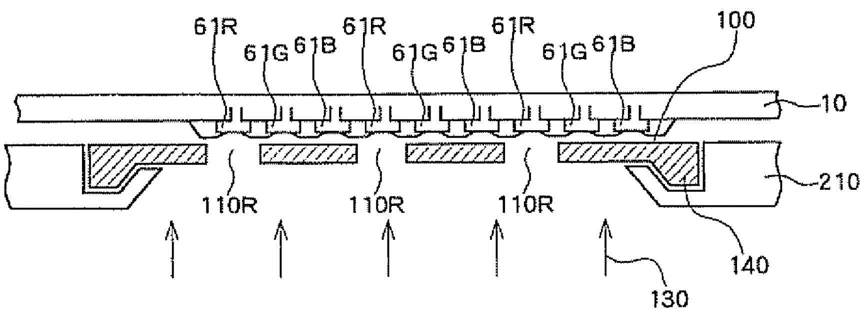

61R
61G
61B
61R
61G
61B
61R
61G
61B
100
10
210
110R
110R
110R
140
130

Fig. 8B

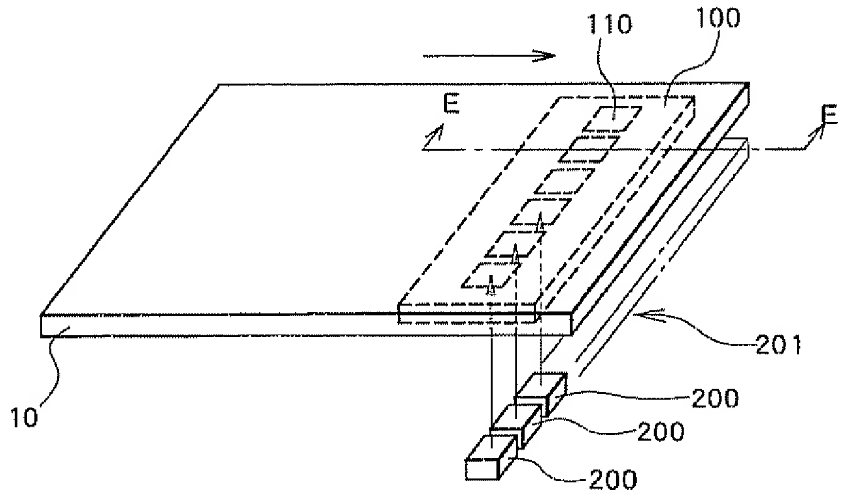


Fig. 9A

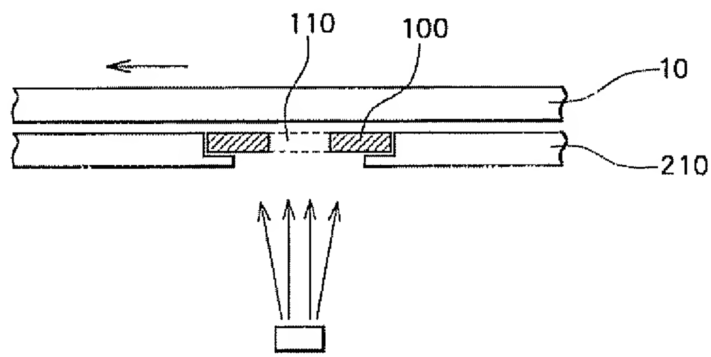


Fig. 9B

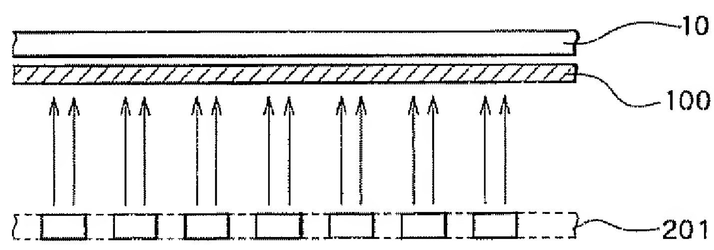


Fig. 9C

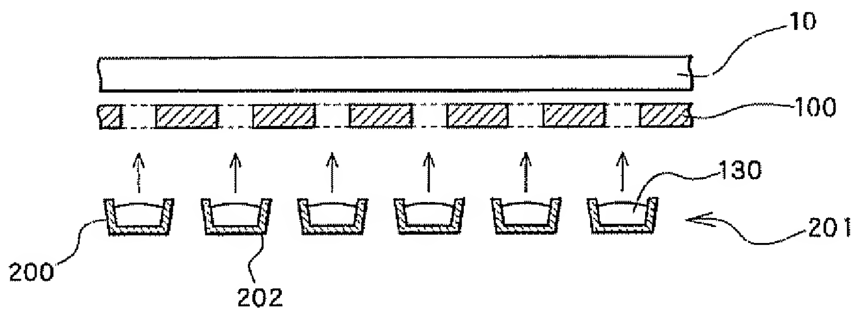


Fig. 10A

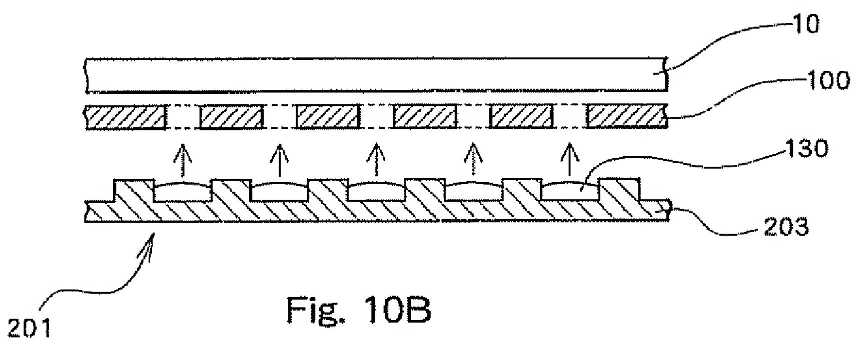


Fig. 10B

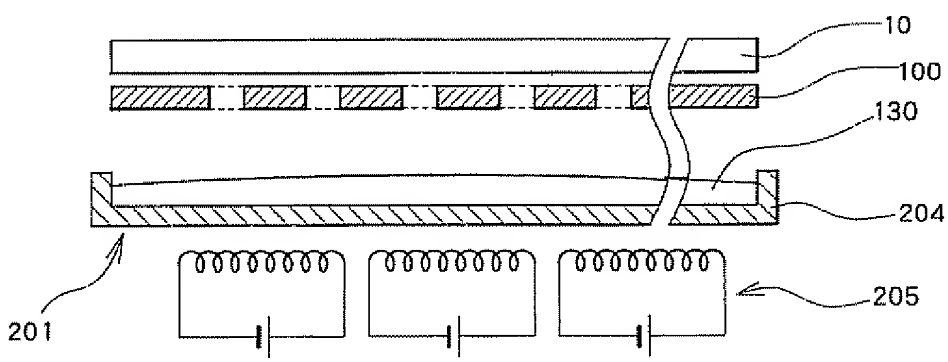


Fig. 10C

METHOD OF ATTACHING LAYER MATERIAL AND FORMING LAYER IN PREDETERMINED PATTERN ON SUBSTRATE USING MASK

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a color display device employing an electroluminescent (hereinafter referred to as "EL") element as an emissive element, and a method of manufacturing such a color display device.

[0003] 2. Description of the Related Art

[0004] In recent years, EL display devices comprising EL elements have gained attention as potential replacements for CRTs and LCDs.

[0005] Research has been directed to the development of active matrix EL display devices comprising a thin film transistor (hereinafter referred to as a "TFT") as a switching element for driving the EL element.

[0006] FIG. 1 is a diagram illustrating an arrangement of display pixels 1R, 1G, and 1B for respective colors in a color organic EL display device.

[0007] As shown in the figure, the active matrix organic EL display device includes the display pixels 1R, 1G, and 1B for red (R), green (G), and blue (B), respectively, which are formed in regions on a substrate 10 surrounded by a gate signal line 51, a drain signal line 52, and a power source line 53. In this example, the display pixels 1R, 1G, and 1B for the respective colors are arranged as stripes in a column direction forming a sequence of R, G, and B in a row direction, collectively constituting a matrix.

[0008] The display pixels 1R, 1G, and 1B for the respective colors are each provided with an EL element for emitting the corresponding color of light, namely, R, G, or B.

[0009] The EL element formed for each of the respective color display pixels 1R, 1G, and 1B includes an anode formed in the island pattern, an emissive element layer including an organic compound, and a cathode. The emissive element layer includes at least an emissive layer, and is formed by evaporating an organic material onto the anode. On top of this layer, the cathode is formed. The anode of the EL element is connected to a TFT, which individually drives each EL element. By thus controlling the TFT and supplying current between the anode and the cathode, the emissive material contained in the emissive element layer is caused to emit the respective color of light.

[0010] FIG. 2 is a cross sectional view illustrating how a metal mask is mounted for evaporating an organic material for each color onto the glass substrate (the anode) according to a related art. At this stage, the TFT, anodes 61R, 61G, and 61B of organic EL elements 60, and an insulating film 68 covering an area surrounding the anodes are preformed on the glass substrate 10. Although each of the anodes 61R, 61G, and 61B is connected to the TFT for driving the organic EL element, the TFT is not shown for convenience of illustration. This figure illustrates an example in which the organic material for emitting red light is evaporated onto the anode 61R to form the emissive element layer for red.

[0011] As shown in FIG. 2, according to the related art, the metal mask 95 used for evaporation of the organic material is a single large mask corresponding to the large-sized glass substrate 10.

[0012] A metal mask 95 formed of a metal, such as a nickel (Ni), is fixed into an evaporation mask holder 125 including a mask fixing portion at its periphery, and has an opening 110R at a position corresponding to the anode 61R. The metal mask 95 is placed between the glass substrate 10, having components up to the TFTs and the anodes 61R, 61G, and 61B of the organic EL elements formed thereon with its component bearing side facing downward, and an evaporation source 200 provided further below, as illustrated in FIG. 2. Because the metal mask 95 is very thin, having a thickness of approximately 50 μm, when the peripheral portions of the metal mask 95 are placed in grooves formed in the mask fixing portion provided at its periphery to thereby fix the metal mask 95 by means of a fixture 126 provided on the mask, the metal mask 95 is fixed and held in tension applied in the direction of the mask holder 125 to prevent such a thin mask from deflecting. In addition, a magnet 120 is placed on a side of the glass substrate 10 opposite from the side on which the metal mask 95 is arranged, thereby attracting the metal mask 95 and preventing warping thereof.

[0013] After the mask 95 and the substrate 10 are thus disposed, an organic material 130 for emitting red light, in this example, is evaporated from the evaporation source 200 onto a region including the anode 61R on the glass substrate 10, thereby depositing the emissive element layer for red color.

[0014] After evaporating the organic material for the red emissive element layer, organic materials for the emissive element layers for green and blue are similarly evaporated, thereby forming the emissive element layers for R, G, and B on the respective anodes 61R, 61G, and 61B.

[0015] The metal mask 95 used in the related art is a single mask similar in size to the large-sized glass substrate 10, such as 400 mm×400 mm, and a single, dot-like evaporation source is used as the evaporation source 200.

[0016] When a single, large-sized metal mask is thus used, it becomes extremely difficult to form a mask with a high precision as the size of the mask increases, and shadowing, i.e. blocking the evaporated material scattered from the source by the edges of the mask in the openings, also becomes more prominent in the peripheral region of the glass substrate 10.

[0017] To overcome such problems, the metal mask must be reduced in thickness to diminish shadowing and be brought into contact with the glass substrate.

[0018] However, when the mask is brought into contact with the substrate, the anodes, the organic material, and other components formed on the glass substrate may be damaged by the mask.

SUMMARY OF INVENTION

[0019] The present invention has been conceived in view of the above-described problems, and aims to provide a method of attaching a layer material, such as an emissive material, onto a predetermined position of a substrate with

a high precision to form a layer in a desired pattern without generating a scar with a mask and the like

[0020] According to one aspect, the present invention provides a method of forming an individually patterned layer in a plurality of regions of a substrate, comprising the step of disposing between the substrate and a layer material source a mask including an opening corresponding to one or more of the plurality of regions where the layer is formed, and the step of making a relative movement between the mask and the layer material source, and the substrate, and causing a material scattered from the layer material source to attach onto the substrate through the opening, thereby forming the individually patterned layer

[0021] According to another aspect, the present invention provides a method of forming an individually patterned layer in a plurality of regions of a substrate, comprising the step of disposing between the substrate and a layer material source a mask having a smaller area than the substrate and including an opening corresponding to one or more of the plurality of regions where the layer is formed, and the step of causing relative movement between the mask and the layer material source, and the substrate, and causing a material scattered from the layer material source to attach onto the substrate through the opening, thereby forming the individually patterned layer

[0022] According to a further aspect, the present invention provides a manufacturing method of a color emissive device including, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels This manufacturing method comprises the step of disposing between the substrate and an emissive material source a mask including an opening at a position corresponding to a region for forming the emissive material layer of one or more of the plurality of pixels of the substrate, and the step of sliding a relative position between the mask and the emissive material source, and the substrate, by a predetermined pitch corresponding to a size of the pixel of the substrate, and causing an emissive material to attach to a predetermined region of the substrate through the mask, thereby forming the emissive material layer

[0023] According to a further aspect, the present invention provides a manufacturing method of a color emissive device including, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels. This manufacturing method comprises the step of disposing between the substrate and an emissive material source a mask including an opening at a position corresponding to a region for forming the emissive material layer of one or more of the plurality of pixels of the substrate, and having a smaller area than the substrate to cover one or more of the plurality of pixels on the substrate, and the step of sliding a relative position between the mask and the emissive material source, and the substrate, by a predetermined pitch corresponding to a size of the pixel of the substrate, and causing an emissive material to attach to a predetermined region of the substrate through the mask, thereby forming the emissive material layer.

[0024] According to a further aspect of the present invention, the substrate of the above-described emissive device is slid in two directions of the substrate perpendicular to each other, or in one direction of the substrate by a pitch corresponding to an arrangement of the pixels for a same color.

[0025] According to a further aspect of the present invention, the layer material source or the emissive material source is a linearly extending source elongated in a direction perpendicular to a direction of the relative movement between the mask and the layer material source or the emissive material source, and the substrate

[0026] According to a further aspect of the present invention, the linearly extending source is formed by a plurality of layer material sources arranged adjacent to each other

[0027] By thus causing evaporation of a material in a material source while shifting a relative position between the material source and the mask, and the substrate, a material layer can be formed on the substrate through the opening formed in the mask with high positional and patterning accuracies Because a mask having a smaller area than the substrate is employed as described above, the mask can be provided with a high strength and the opening formed with a high accuracy, and variation in distance between the material source and the respective positions of the mask can be reduced, making it possible to form the material layer at a plurality of positions of the substrate with a very high accuracy and balanced characteristics

[0028] According to a further aspect of the present invention, the layer is an electroluminescent layer formed between first and second electrodes, and the layer material is an electroluminescent material.

[0029] According to a further aspect of the present invention, the electroluminescent material is an organic material scattered from the layer material source by evaporation and attached to the substrate, thereby forming the electroluminescent layer

[0030] According to a further aspect of the present invention, the self-emissive element is an electroluminescent element

[0031] According to a further aspect of the present invention, the emissive device is a display device for displaying an image with a plurality of pixels.

[0032] As described above, the method according to the present invention allows formation of the individually patterned material layer at predetermined positions of the substrate as desired with a high accuracy. Consequently, emissive material layers for different colors, for example, can be formed with a high accuracy, so that color emissive devices and display devices presenting vivid and uniform colors can be manufactured.

[0033] According to a further aspect of the present invention, a semiconductor material is used for the mask

[0034] Use of a semiconductor material for the mask enables formation of the opening by photolithography with a high accuracy and a sufficient strength to be maintained, thereby contributing to improvement in accuracy of patterning the material layer to be formed, and facilitating handling of the mask to, for example, increase life of the mask, so that the cost of manufacturing a device using such a mask can be reduced

[0035] According to a further aspect, the present invention provides a manufacturing method of a display device includ-

ing, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels This manufacturing method comprises the step of disposing between the substrate and an emissive material source a mask including an individual opening for each pixel corresponding to a region for forming the emissive material layer individually patterned for each of the plurality of pixels, and the step of sliding a relative position between the emissive material source and the substrate and causing an emissive material to attach to a predetermined region of the substrate through the opening of the mask, thereby forming the emissive material layer

[0036] According to a further aspect of the present invention, in the above manufacturing method of a display device, the emissive material source is a linearly extending source elongated in one direction

[0037] Thus, when the emissive material layer is formed in individual patterns for the respective pixel regions, the opening corresponding to the individual pattern is formed in the mask, and the material is attached to the substrate while the emissive material source and the substrate are moved relatively Consequently, the emissive material source is located equally close to each region for forming the emissive material layer on the substrate, thereby preventing variation in thickness of the emissive material layer formed in each of such regions caused by shadowing

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] **FIG. 1** is a plan view illustrating an arrangement of display pixels for respective colors in an EL display device

[0039] **FIG. 2** is a cross sectional view illustrating an evaporation method according to a related art

[0040] **FIG. 3** is a plan view illustrating an evaporation method according to a first embodiment of the present invention

[0041] **FIG. 4** is a cross sectional view illustrating an evaporation method according to the embodiments of the present invention

[0042] **FIG. 5** is a plan view illustrating an area surrounding the display pixel of the EL display device.

[0043] **FIGS. 6A** and **6B** are cross sectional views taken along the lines B-B and C-C in **FIG. 5**, respectively

[0044] **FIG. 7** is a view for explaining a process for evaporating an emissive material onto the respective display pixels of the EL display device

[0045] **FIG. 8A** is a perspective view illustrating an evaporation method using a mask

[0046] **FIG. 8B** is a view illustrating a cross sectional structure taken along the line D-D in **FIG. 8A**

[0047] **FIGS. 9A, 9B**, and **9C** are views for explaining an evaporation method according to a second embodiment of the present invention

[0048] **FIGS. 10A, 10B**, and **10C** illustrate specific configuration examples of a linearly extending source according to the present invention

DESCRIPTION OF PREFERRED EMBODIMENTS

[0049] An organic EL display device manufactured by a manufacturing method of a color display device according to the present invention will next be described

[0050] **FIG. 3** shows a planar configuration used for explaining a method for moving an insulating substrate onto which an organic material is evaporated according to the present method of manufacturing a color display device, and **FIG. 4** shows a cross sectional configuration taken along the line A-A in **FIG. 3**. It should be noted that **FIG. 4** shows the cross section at the step of evaporating an organic emissive material for each color by an evaporation method onto an insulating substrate, such as a glass substrate **10**, having components up to a TFT, an anode of an organic EL element, and an insulating film **68** for covering an area surrounding the anode, and that in this particular example an emissive element layer for red is deposited onto an anode **61R** through evaporation

[0051] An evaporation mask **100** is disposed between the glass substrate **10** and an evaporation source **200** containing an organic material for the particular color to be evaporated In contrast to the related art, this evaporation mask **100** has a smaller area than the glass substrate **10** and partially covers the substrate **10** In the region of the glass substrate **10** that is not covered with the evaporation mask **100**, a mask supporting member **210** is present The evaporation mask **100** is supported at an end by the mask supporting member **210** formed of a metal While an opening **211** is provided at the position of the mask supporting member **210** where the evaporation mask **110** is disposed to allow the evaporated organic material to reach the glass substrate **10** through the evaporation mask **100**, in the remaining area the glass substrate **10** is shielded from the evaporation source **200**

[0052] As illustrated in the figure, the evaporation source **200** is disposed immediately below the mask **100** so that the material can be efficiently and selectively evaporated onto a restricted area, i e the area of the opening formed in the evaporation mask **100** in this example

[0053] Further, in this example, the glass substrate **10** is divided into four evaporation regions "a", "b", "c", and "d" for evaporation of the organic material onto the glass substrate, as illustrated in **FIG. 3**

[0054] More specifically, after an organic emissive material for red is first evaporated onto the evaporation region "a" (the region defined by the solid line), the glass substrate **10** is slid in the X direction, and the organic emissive material for red is evaporated onto the evaporation region "b" (defined by the one-dot chain line) The glass substrate **10** is then slid in the Y direction, and the red organic emissive material is evaporated onto the evaporation region "c" (defined by the broken line). Finally, the glass substrate **10** is slid in the X direction, and the red organic emissive material is evaporated onto the evaporation region "d" (defined by the two-dot chain line) By thus dividing the substrate into a plurality of regions for evaporation, the organic emissive material can be evaporated onto the anode **61R** corresponding to the red emissive pixel on the single glass substrate **10** using the evaporation mask **100** having a smaller area than the substrate

[0055] The organic emissive materials for green and blue are each evaporated in a reaction chamber dedicated for each

color using a mask dedicated for each color and having a smaller area than the substrate 10 as illustrated in FIG. 4, namely, an evaporation mask for green and an evaporation mask for blue. For such evaporations, the glass substrate 10 is slid in the X and Y directions to evaporate each color onto the respective regions "a", "b", "c", and "d", similarly to evaporation of red. Thus, the organic emissive materials for the respective colors can be evaporated onto the anodes 61R, 61G, and 61B corresponding to the respective colors.

[0056] FIG. 5 is a plan view illustrating an area surrounding a display pixel of the organic EL display device, and FIGS. 6A and 6B are cross sectional views taken along the lines B-B and C-C, respectively, in FIG. 5.

[0057] As shown in FIG. 5, surrounding the region in which each display pixel is formed are gate lines 51 and drain lines 52. A first TFT 30 serving as a switching element is disposed near an intersection of those signal lines. The source 11*s* of the TFT 30 simultaneously functions as a capacitor electrode 55 such that, together with a storage capacitor electrode line 54 described later, it forms a capacitor. The source 11*s* is connected to a gate 43 of a second TFT 40 for driving the EL element. The source 41*s* of the second TFT is connected to the anode 61 of the organic EL element 60. The drain 41*d* is connected to a power source line 53 which supplies current to the organic EL element 60.

[0058] Near the TFT, the storage capacitor electrode line 54 is disposed in parallel to the gate line 51. The storage capacitor electrode line 54 is made of a material such as chromium. The storage capacitor electrode line 54 opposes the capacitor electrode 55 connected to the source 11*s* of the TFT with a gate insulating film 12 provided in between, and together they form a storage capacitor for storing charges. This storage capacitor is provided for retaining a voltage applied to the gate electrode 43 of the second TFT 40.

[0059] As shown in FIGS. 6A and 6B, the organic EL display device is formed by sequentially laminating the TFTs and the organic EL element on the substrate 10 made of a material such as glass or synthetic resin, or on a conductive or semiconductor substrate. It should be noted that the layers and the like formed in the same step are labeled with the same reference numerals in FIGS. 6A and 6B.

[0060] Next, the first TFT 30, or the switching TFT, will be explained with reference to FIG. 6A.

[0061] On the insulating substrate 10 made of quartz glass, non-alkali glass, or a similar material, an amorphous silicon film (a-Si film) is formed using a CVD or other method. The a-Si film is irradiated with an excimer laser beam to be polycrystallized, forming a polycrystalline silicon film (p-Si film) 11 which serves as an active layer of the TFT 30. The gate insulating film 12 is formed over the p-Si film 11. Further on top is disposed the gate signal line 51 which is made of a refractory metal, such as chromium (Cr) or molybdenum (Mo), and which also serves as a gate electrode 13.

[0062] An interlayer insulating film 14 of an insulating film, such as an SiO_2 film, is then provided over the entire surface of the gate insulating film 12, the gate electrode 13, the driving power source line 53, and the storage capacitor electrode line 54. A metal such as aluminum (Al) is filled in a contact hole provided corresponding to the drain lid to form the drain signal line 52, which also serves as a drain electrode 15. Further, a planarizing insulating film 16 made of a photosensitive organic resin or a similar material is formed covering the entire surface for planarization. Further on top, a hole transport layer 63, an electron transport layer 65, and a cathode 67 of the organic EL element 60 are provided over the entire surface.

[0063] The second TFT 40, or the TFT for driving the organic EL element, will next be described with reference to FIG. 6B.

[0064] As shown in FIG. 6B, sequentially formed on the insulating substrate 10 made of a material such as quartz glass or non-alkali glass are an active layer 41 composed of a p-Si film disposed at the same time with the active layer of the first TFT 30, the gate insulating film 12, and the gate electrode 43 made of a refractory metal such as Cr or Mo. The active layer 41 includes a channel 41*c*, and, on respective sides of the channel 41c, a source 41*s* and a drain 41*d*. The above-described interlayer insulating film 14 composed of an SiN film, and an SiO_2 film stacked in this order is provided on the entire surface over the active layer 41 and the gate insulating film 12. A contact hole formed through the interlayer insulating film 14 and the gate insulating film 12 in a position corresponding to the drain 41*d* is filled with a metal, such as Al, integrally with the power source line 53 connected to a power source. Further, the planarizing insulating film 16 made of an organic resin or a similar material is formed over the entire surface for planarization. A contact hole is then formed through the planarizing insulating film 16, the interlayer insulating film 14, and the gate insulating film 12 in a position corresponding to the source 41*s*. A transparent electrode made of ITO (indium tin oxide) that contacts the source 41*s* through this contact hole, namely, the anode 61 of the organic EL element, is formed on the planarizing insulating film 16.

[0065] The organic EL element 60 includes the anode 61 constituted by a transparent electrode made of ITO or a similar material, an emissive element layer 66 composed of a plurality of organic layers, and a cathode 67, which may be composed of a magnesium-indium alloy, stacked in this order. This emissive element layer 66 includes, for example, a first hole-transport layer 62 composed of a material such as MTDATA (4,4,4tris(3-methylphenylphenylamino)triphenylamine), a second hole-transport layer 63 composed of a material such as TPD (N,N'-diphenyl-N,N'-di(3-methylphenyl)-1,1'-biphenyl-4,4'diamine), an emissive layer 64 composed of, for example, $Bebq_2$ bis(10-hydroxybenzo[h]quinolinato)beryllium) including quinacridone derivatives, and an electron transport layer 65 composed of $Bebq_2$ or a similar material. All of the above-noted layers of the emissive element layer 66 are laminated on the anode in the described order. An insulating film 68 of a photosensitive organic resin is provided between anodes 61 of the organic EL elements 60 for adjacent pixels and covering an edge 69 of the anode 61, thereby preventing short-circuiting between the edge 69 of the anode 61 and the cathode 67. The organic EL element 60 of the above-described configuration constitutes an emissive region (display region) in each display pixel.

[0066] Another example of the structure of the EL element 60 can be constructed by sequentially laminating the layers of (a) transparent layer (anode); (b) a hole transport layer constructed from NBP; (c) an emissive layer including red

(R) constructed by doping a red dopant (DCJTB) into a host material (Alq_3), green (G) constructed by doping a green dopant (coumarin 6) into a host material (Alq_3), and blue (B) constructed by doping a blue dopant (perylene) into a host material (BAlq); (d) an electron transport layer constructed from Alq_3; (e) an electron injection layer constructed from lithium fluoride (LiF); and (f) electrode (cathode) constructed from Aluminum (Al). The official names of the above materials described in abbreviations are as follows:

[0067] "NBP": N,N'-Di((naphthalene-1-yl)-N,N'-diphenyl-benzidine);

[0068] "Alq^3": Tris(8-hydroxyquinolinato)aluminum;

[0069] "DCJTB": (2-(1,1-Dimethlethyl)-6-(2-(2,3,6,7-tetrahydro-1,1,7,7-tetramethyl-1H,5H-benzo[ij]quinolizin-9yl)ethenyl)-4H-pyran-4-ylidene)propanedinitrile;

[0070] "coumarin 6": 3-(2-Benzothiazolyl)-7-(diethylamino)coumarin; and "BAlq": (1,1'-Bisphenyl-4-Olato)bis(2-methyl-8-quinolinplate-N1,08)Aluminum

[0071] The present invention, however, is not limited to these configurations.

[0072] In the organic EL element, holes injected from the anode and electrons injected from the cathode recombine in the emissive layer. As a result, organic molecules contained in the emissive layer are excited, generating excitons. Through the process in which these excitons undergo radiation until deactivation, light is emitted from the emissive layer (emissive material layer) 64. This light radiates outward through the transparent anode 61 via the transparent insulating substrate 10, resulting in light emission.

[0073] As illustrated in FIG. 6B, according to the present embodiment, only the emissive layers 64 of the respective organic EL elements 60 are made of different organic materials depending on the color of light to be emitted, and formed in a pattern similar to the anode 61, i.e. in the island pattern. On the other hand, the hole transport layers 62 and 63 and the electron transport layer 65 are formed of the same organic material for all the EL elements 60 for different colors R, G, and B, and shared by all the pixels. In a display device for displaying monochrome images, the emissive layer 64 is formed over the entire surface similarly to the hole transport layers 62 and 63 and the electron transport layer 65 because the layer can be formed of the identical material for all the organic EL elements 60. The hole transport layers 62 and 63 and the electron transport layer 65 may also be formed as individual patterns, as is the emissive layer 64, when, for example, the layers are formed of different materials for the respective pixels in display devices for presenting either a monochrome image or a multi-color image in R, G, and B.

[0074] FIG. 7 shows in detail the positional relationship between the evaporation mask 100 and the substrate 10 when the emissive layer 64 is formed through evaporation as individual patterns for the respective organic EL elements 60, and corresponds to the partially enlarged cross sectional view of FIG. 4.

[0075] Referring to FIG. 7, on the glass substrate 10 are formed the first and second TFTs and the anodes 61R, 61G, and 61B connected to the second TFT. Further, the insulating film 68 is formed covering the peripheral regions of the anodes 61R, 61G, and 61B, and the hole transport layers 62 and 63 are formed.

[0076] Such a glass substrate 10 is introduced into a vacuum evaporation chamber with its anode bearing side facing downward. In this particular example, the evaporation mask 100 having an opening 110R for a region where the emissive layer for red is formed is arranged such that the opening 110R is aligned with the anode 61R of the red display pixel. The organic emissive material for emitting red light is evaporated from an unillustrated evaporation source disposed below the elements in the figure, so that the emissive layer is evaporated onto the anode 61 (more precisely, on the hole electron layers 62 and 63 in FIG. 7) corresponding to the opening 110R of the evaporation mask 100.

[0077] The evaporation mask used in the present embodiment will next be described in detail. As described above, the evaporation mask employed in the present embodiment is smaller in size than the substrate 10, and the region of the substrate 10 that is not covered with the evaporation mask is shielded from the evaporation source 201 by the supporting member 210, as illustrated in FIG. 4. According to the present embodiment, a mask smaller than the substrate 10 on which elements are formed is used for the evaporation mask 100. In other words, a small-sized mask that can be formed with a sufficiently high precision can be employed even when the substrate 10 is large. As a result, even when a metal mask of nickel (Ni) or the like is used as in the above description, the present embodiment allows the mask to have a thickness with a sufficient strength and shadowing to be reduced. When the metal mask is used for the evaporation mask in the present embodiment, the mask supporting portion of the supporting member 210 illustrated in FIG. 4 preferably has a fixing mechanism for fixing the metal mask while applying tension thereto in its peripheral direction as illustrated in FIG. 2.

[0078] Next, another exemplary evaporation mask will be described with reference to FIGS. 8A and 8B. FIG. 8A is a perspective view illustrating the glass substrate 10 in contact with the evaporation mask 100, wherein the glass substrate 10 includes preformed components, namely, the first and second TFTs, the anode 61 and the insulating layer 68 of the organic EL element 60, and the hole transport layer (not shown) shared by all pixels, similarly to the configuration in FIG. 7. FIG. 8B schematically shows cross sectional configurations of the glass substrate 10, the mask 100, and the mask supporting member 210, taken along the line D-D in FIG. 8A.

[0079] The evaporation mask 100 illustrated in FIGS. 8A and 8B is formed of a monocrystalline silicon (Si) substrate having a thickness of, for example, 0.5 mm, and has a greater thickness portion 140 of 10 μm to 50 μm in thickness in its peripheral region. While the greater thickness portion 140 is not always necessary, the greater thickness in the peripheral region of the mask 100 contributes to increase in strength of the evaporation mask 100. Such an evaporation mask 100 is disposed in contact with, or close to, a lower surface of the evaporation object, i.e. the glass substrate 10 having the predetermined layers up to those described above. The organic material is evaporated from the unillustrated evaporation source disposed at the lower part of the

figure, thereby evaporating the organic material onto the portion of the substrate 10 exposed by the opening 110 of the evaporation mask 100 The evaporation mask 100 in the example of FIGS. 8A and 8B is a mask for red color, and, when the pixels for R, G, B are arranged in this sequence in the row direction as illustrated in FIG. 1, the evaporation mask 100 has the openings 110R arranged in the column direction and corresponding to the regions where the organic EL elements for red are formed in every third column

[0080] When the evaporation mask 100 is formed of a silicon substrate as in the present embodiment, the opening for the selective mask can be formed by etching the silicon substrate with the photolithography technique widely used in the art of semiconductor, making it possible to readily form the opening with a high precision. Further, the organic material attached to a surface of the silicon substrate by evaporation of the material performed a plurality of times using the evaporation mask 100 of the silicon substrate can easily be removed, thereby allowing repeated use of the evaporation mask 100 Because the silicon substrate is highly resistant to etchant used for etching away the organic material attached to the surface, the mask can be more repeatedly used, contributing to reduction in manufacturing cost

[0081] As described above, a mask smaller in size than the glass substrate 10, or the evaporation object, is used, as opposed to the related art in which a single large mask is used for the entire surface of the large-sized glass substrate, whereby the evaporating source can always be disposed immediately under the evaporation mask, that is, relatively speaking, immediately below the evaporation region. Consequently, the evaporated material, or the organic material, can always be evaporated to the respective pixel regions (emissive regions) from the vertical direction This can prevent undesirable evaporation caused by the material scattering around and being deposited on adjacent anodes, and deviation of evaporation position, and avoid shadowing, which is caused by the thickness of the opening of the evaporation mask and by the fact that the evaporated material scatters over a wide area because the evaporation source is not located immediately under the opening

[0082] A second embodiment of the present invention will next be described with reference to FIGS 9A-9C FIG. 9A is a perspective view for explaining the evaporation process, FIG. 9B schematically shows the cross section taken along the line E-E in FIG. 9A, and FIG C shows the evaporation process of FIG. 9A from the right side Similarly to the first embodiment, the substrate 10 having the components preformed thereon, namely, the first and second TFTs, the anode of the organic EL element, the insulating layer covering the edge of the anode, and the hole transport layer (when it is formed over the entire surface), is disposed with its element bearing side facing downward The evaporation mask 100 is disposed on this element bearing side of the substrate 10

[0083] For the evaporation mask 100, a silicon mask formed of a silicon substrate is used similarly to the mask shown in FIGS. 8A and 8B (although the metal mask may be used) The evaporation mask 100 in this example includes openings 110 corresponding to a single column of pixels to serve for the pixel regions for the same color arranged in the column direction on the glass substrate 10 Immediately under such openings 110 of the evaporation mask 100, a plurality of evaporation sources 200 are disposed. The plurality of evaporation sources 200 are arranged in a direction in which the openings 110 of the evaporation mask 100 are arranged, thereby collectively forming a linearly extending source 201 arranged in a straight line in the column direction, as illustrated in FIG. 9C, in this particular example.

[0084] As shown in the above-noted figures, the evaporation mask 100 corresponding to a limited set of display pixels is used for evaporation, rather than evaporating the material onto the entire surface of the large glass substrate using a single metal mask as in the related art Therefore, the evaporation sources can be disposed immediately under the openings 110 of such an evaporation mask, thereby causing the organic material scattered from the evaporation sources 200 with a vertical directivity to attach onto the glass substrate Consequently, undesirable attachment of the organic material onto adjacent anodes and deviation of position at which the emissive layer is formed can be prevented

[0085] For evaporating the evaporation material from the evaporation source onto the glass substrate 10, in this example the glass substrate 10 is slid by a predetermined pitch from the right to the left in the figure, i.e. in the direction along a pair of sides of the substrate 10 or along the row of the matrix on the substrate 10, or in the direction perpendicular to the direction in which the openings 110 of the evaporation mask 100 and the linearly extending source 201 are arranged Alternatively, the evaporation mask 100 and the evaporation sources 200 may be moved relative to the substrate 10, rather than moving the substrate 10, while maintaining the positional relationship between the openings 110 of the evaporation mask 100 and the respective evaporation sources 200. In either case, the openings 110 of the evaporation mask 100 and the evaporation sources 200 are arranged in a direction perpendicular to the direction of relative movement between the substrate 10, and the evaporation mask 100 and the evaporation sources 200

[0086] The method of sliding the glass substrate 10 will next be described The opening 110 of the evaporation mask 100 is first aligned with the red display pixel 1R in a given column, and the organic material for red is evaporated from the evaporation source 200 The glass substrate 10 is then slid by a predetermined pitch (every third column, for example, when the pixels for R, G, B are arranged as stripes in this order), so that the evaporation mask 100 is aligned with the red display pixel 1R in the next red column and the red organic material is evaporated By repeatedly performing such evaporation and substrate sliding steps, the organic material for red can be evaporated onto each anode for the red display pixels formed on the glass substrate 10 Upon positioning of the evaporation mask 100, when the precision in alignment between the evaporation mask 100 and the anode on the substrate 10 can be maintained, the mask 100 must be aligned therewith only for the first evaporation, and it is not necessary to align these elements every time the substrate 10 is slid Such an approach is preferable because it contributes to improvement in throughput of the process

[0087] Evaporation for the green and blue display pixels 1G and 1B, respectively, arranged in the column direction next to the red display pixel 1R as shown in FIG. 1 can be performed in a similar manner to the evaporation for red

More specifically, the glass substrate **10** is slid, and evaporation is sequentially performed from the anode on one side of the substrate **10** to the anode on the other side thereof. Thus, the organic materials for the respective colors can be provided on the anodes **61R**, **61G**, and **61B** corresponding to the respective display pixels **1R**, **1G**, and **1B**

[0088] As illustrated in **FIG. 9B**, the evaporation mask **100** is fixed to the supporting member **210** having an opening in a region for disposing the evaporation mask as that shown in **FIG. 4**, and the region of the substrate **10** that is not covered with the evaporation mask **100** is shielded from the evaporation source **200** by the supporting member **210**

[0089] The evaporation mask **100** may have more than one column of openings **110** (only for the pixels of the identical color), rather than a single column of openings as illustrated in **FIG. 9A** When the openings **110** are provided in an increased number of columns, however, the evaporated material scatters obliquely for the opening **110** formed at a position distant from the linearly extending source **201** extending in the column direction Therefore, the number of columns of the openings **110** in a single evaporation mask **100** is preferably determined taking into consideration the distance between the evaporation source **200** and the glass substrate **10**, and the scattering direction of the evaporated material.

[0090] Further, similarly to the number of columns described above, the number of openings **110** provided in the evaporation mask **100** may not be the same as the total number of anodes arranged in one column among the anodes for a plurality of pixels on the glass substrate **10** as illustrated in **FIG. 9A**, and may be smaller than this number. When such a smaller number of openings are provided, an evaporation mask **100** that is smaller in size in both row and column directions than the large-sized substrate **10** of, for example, 400 mm×400 mm is used The evaporation mask **100** and the substrate **10** are first arranged such that some of the anodes of pixels in the column direction overlap the openings **110** of the mask **100**. The substrate **10** is then sequentially slid to the end in the row direction while the organic layer is formed by evaporation Next, the relative position between the substrate **10** and the mask **100** is shifted in the column direction by the distance corresponding to the number of openings **110** provided in the mask **100**, and the substrate **10** is again slid in the row direction while the evaporation process is performed. Such a procedure is repeatedly conducted until the organic layer is evaporated onto all of the necessary pixel regions on the substrate

[0091] The number of columns of the openings **110** of the evaporation mask **100** and the number of openings in a column are preferably maximized while suppressing shadowing by the evaporation mask **100** caused by the evaporated material from the evaporation source **200** being scattered in an oblique direction, and undesirable evaporation onto other pixels. This is because a larger number of openings **110** result in a wider area to be evaporated by a single evaporation, leading to a higher throughput of the evaporation process

[0092] When a plurality of evaporation sources **200** are arranged in the column direction to form a linearly extending source **201** as illustrated in **FIG. 9A** and the size of the evaporation mask **100** is the same, shadowing or undesirable evaporation onto other pixels can significantly be reduced as compared to the case where the organic layer is formed by evaporation onto the anodes for a plurality of pixels by a single (dot-like) evaporation source **200**. This is because, as the evaporation sources are arranged in the column direction by employing the linearly extending source **201** as illustrated in **FIG. 9C**, the evaporation material is scattered more vertically, thereby making uniform the direction of the scattering evaporation material from the evaporation mask **100** to the respective openings **110**

[0093] It should be noted that the organic materials having, for example, an emissive function and used for the organic EL elements for the respective colors are evaporated onto the pixel regions for the corresponding colors in different chambers (chambers where different evaporation sources are set) using different masks

[0094] Next, the movement pitch of the above-described substrate **10** when the substrate is slid will be described.

[0095] When the openings of the evaporation mask **100** are arranged in a direction perpendicular to the sliding direction of the substrate **10** as described above and the display pixels **1R**, **1G**, and **1B** are arranged as stripes as shown in **FIG. 1**, the openings **110** of the evaporation mask **100** are moved to every third column corresponding to, for example, the repeatedly arranged display pixels **1R**, skipping the display pixels **1G** and **1B**. Thus, the sliding pitch corresponds to 3 columns when the arrangement as shown in **FIG. 1** is employed More precisely, the process can be performed by sliding the substrate **10**, or changing the relative position between the substrate and the evaporation mask **100**, corresponding to the repeatedly arranged red display pixels **1R**

[0096] As described above, according to the second embodiment of the present invention, the evaporation mask **100** smaller in size than the substrate **10** is employed to evaporate the organic material for the identical color onto the substrate **10** a plurality of times Further, the linearly extending source **210** extending in the direction in which the evaporation mask **100** is provided is employed As a result, variation in evaporating conditions for the respective openings **110** is reduced, thereby preventing variation in thickness of the evaporation layer Consequently, problems, such as variation in tone of the same color between the central portion and the peripheral portion of the glass substrate **10**, can be avoided, and the organic material to be evaporated onto a given anode is prevented from reaching and being attached onto the adjacent anodes for different color pixel regions, thereby preventing blurring caused by color mixture.

[0097] Further, flexure of the evaporation mask **100** according to the second embodiment is very small because a sufficient strength is provided to the mask This feature further ensures prevention of problems, such as the opening **110** and the metal mask **100** becoming misaligned from the central portion toward the peripheral portion of the mask **100** Such a misalignment shifts the position where the emissive material is actually evaporated from the anode **61** onto which the organic material must be evaporated, as a result of which a given color cannot be emitted in the EL display device. As a result, color blurring can be eliminated and vivid display of a desired color can be achieved

[0098] While in the above-described first and second embodiments only several openings of the evaporation mask

are illustrated for clarity of illustration, in actual fact more openings are formed When, for example, a plurality of display device regions are simultaneously formed on the same substrate **10**, the openings are formed in a number corresponding to (e g. the total number or a submultiple of) display device regions having the pixels of, for example, 852 (columns)×222 (rows)

[0099] Further, while in the above-described first embodiment the single large substrate **10** is divided into four evaporation regions as shown in **FIG. 3**, naturally the number by which the substrate is divided is not limited to four in the present invention However, because the insulating substrate is slid in vertical and horizontal directions of **FIG. 3** (X and Y directions, respectively) for evaporation, this number is preferably an even number in light of the evaporation process efficiency

[0100] While the display pixels for the respective colors are described as being arranged as stripes in the above embodiments, other arrangements are also possible, and the present invention can also be applied to a display device having display pixels in the so-called delta arrangement or in a variety of other arrangements. In such a case, the present invention can be readily implemented by using an evaporation mask having openings corresponding to the arrangement of the respective color display pixels

[0101] Further, as described in connection with the second embodiment, the number of evaporation sources disposed below the evaporation mask may be set such that the organic material scattered onto the glass substrate has the directivity as close as possible to the right angle to the substrate. More specifically, the number may be determined in accordance with the distance between the glass substrate and the evaporation source, and with a predetermined thickness of the organic material layer formed on the anode It should be noted, however, that, when a plurality of separate evaporation sources are arranged, the organic material can be efficiently and uniformly evaporated to the respective openings by providing one evaporation source for each opening, or providing as many evaporation sources as possible if such a one-on-one provision is impossible

[0102] Next, a specific example and variations of the linearly extending source employed in the above-described second embodiment will be described with reference to FIGS **10A-10C** **FIG. 10A** illustrates a more specific configuration of the linearly extending source **201** shown in **FIG. 9A** Referring to **FIG. 10A**, each evaporation source **200** is formed by a container **202** containing the evaporation material (such as emissive material) 130, and such sources are linearly arranged to constitute the linearly extending source **201** It should be noted that each evaporation source **200** can heat the evaporation material **130** by means of an unillustrated individual heater The linearly extending source **201** illustrated in **FIG. 10B** includes a plurality of material cells formed in a single container **203**, each containing the evaporation material **130** One or more unillustrated heaters heat the evaporation material **130** in each material cell to cause evaporation As described above, each material cell may be disposed corresponding to the position of the opening **110** in the mask **100**, or to a plurality of openings **110** The linearly extending source **201** illustrated in **FIG. 10C** is formed by a single container **204** elongated in one direction and containing the evaporation material **130**. A plurality of heaters **205** are provided to heat and evaporate the evaporation material **130**

[0103] The structure in **FIG. 10A** is advantageous in that the independently provided evaporation source **200** can be individually controlled, and that the evaporation source **200** with a malfunction can be individually replaced Because a single container **203** is employed for the linearly extending source **201** illustrated in **FIG. 10B**, the source can be easily moved or heated, facilitating the control In addition, the container **203** can be designed such that the material cell is placed corresponding to each opening **110** of the mask **100** to the greatest extent possible, as illustrated, thereby reducing the amount of material scattered from the evaporation source to the region where the opening is not provided, and achieving a high efficiency in use of the material similarly to the linearly extending source **201** in **FIG. 10A** The linearly extending source **201** illustrated in **FIG. 10C** can be easily controlled upon, for example, movement because a single container **204** is employed By using a plurality of heaters **205** as illustrated in **FIG. 10C**, the optimum heating environment can be realized by individually controlling the respective heaters **205**, and, when some of the heaters **205** break down, the rest of the heaters **205** can heat the evaporation material **130** compensating for the failed heaters

[0104] As described above, the differently configured sources **201** extending in a linear manner have different characteristics By choosing an appropriately configured source **201** for the particular use, the evaporation process can be smoothly performed, and reduction in cost and improvement in accuracy can be achieved

[0105] The mask **100** having an smaller area than the substrate **10** is employed in the above description. When the linearly extending source **201** as illustrated in FIGS **10A-10C** is employed and moved relative to the substrate, a uniform evaporation layer can be formed in each region even by employing, for example, a mask similar in size to the substrate **10** and having a plurality of openings corresponding to the individual patterns of the evaporation layer for the plurality of pixels on the substrate **10** When the openings **110** are formed in the individual patterns in the mask corresponding to the respective pixels, greater effects of shadowing and the like are observed in the openings **110** located farther from the evaporation source if the relative position between the evaporation source and the substrate remains unchanged However, by employing the relatively large source **201** extending in a linear manner as illustrated in FIGS **10A-10C**, and moving the source **201** or the substrate **10** and the mask **100** fixedly aligned with the substrate **10**, the source can be positioned equally close to the respective regions for forming the evaporation layer on the substrate **10**, and in particular the source always passes immediately below each region Consequently, the individually patterned evaporation layer can be uniformly formed for each pixel on the substrate When the throughput of the evaporation process is sufficiently high, a single dot-like evaporation source **200** may be used and moved relative to the substrate **10** rather than using the large linearly extending source **201** With any of the above-described sources, a large-sized mask **100** may also be used as long as inaccurate positioning of the opening **110** with respect to the evaporation layer formation region due to flexure and the like can be avoided

[0106] Although the display device has been described as being an active matrix display device including a TFT for each pixel as a switching element, the switching element is not limited to a TFT and may be a diode or the like. Further, the display device is not limited to the active matrix color display device, and the present invention may be applied to formation of an individual evaporation layer for each pixel, column, or row of a substrate having a large area in a passive matrix display device where a switching element is not formed for each pixel. In other words, by employing an evaporation mask smaller than the large-sized substrate and causing relative movement between the evaporation mask and the evaporation source, and the substrate, a uniform evaporation layer can be accurately formed at any position of the substrate.

[0107] Further, while organic EL display devices are described in the above-described embodiments, the present invention is not limited thereto, and is also applicable to a commonly used vacuum fluorescent display (VFD) including self-emissive elements. In a VFD, an anode, a filament, and a fluorescent material layer provided on the anode correspond to an anode, a cathode, and an emissive element layer of an organic EL element, respectively. When the present invention is applied to a VFD, the material is attached using a mask having an opening at a position corresponding to the fluorescent material layer of a predetermined color. For such attachment, the glass substrate onto which the fluorescent material is attached is slid by the pitch corresponding to a predetermined number of display pixels.

What is claimed is:

1. A method of forming an individually patterned layer in a plurality of regions of a substrate, comprising the steps of:

disposing between said substrate and a layer material source a mask including an opening corresponding to one or more of the plurality of regions where said layer is formed; and

causing relative movement between said mask and said layer material source, and said substrate, and causing a material scattered from said layer material source to attach to said substrate through said opening, thereby forming said individually patterned layer.

2. A method according to claim 1, wherein

said layer material source is a linearly extending source elongated in a direction perpendicular to a direction of the relative movement between said mask and said layer material source, and said substrate.

3. A method according to claim 2, wherein

said linearly extending source is formed by a plurality of layer material sources arranged adjacent to each other.

4. A method according to claim 1, wherein

said layer is an electroluminescent layer formed between first and second electrodes, and

said layer material is an electroluminescent material.

5. A method according to claim 4, wherein

said electroluminescent material is an organic material scattered from said layer material source by evaporation and attached to said substrate, thereby forming said electroluminescent layer.

6. A method according to claim 1, wherein

a semiconductor material is used for said mask.

7. A method of forming an individually patterned layer in a plurality of regions of a substrate, comprising the steps of:

disposing between said substrate and a layer material source a mask having a smaller area than said substrate and including an opening corresponding to one or more of the plurality of regions where said layer is formed; and

causing relative movement between said mask and said layer material source, and said substrate, and causing a material scattered from said layer material source to attach to said substrate through said opening, thereby forming said individually patterned layer.

8. A method according to claim 7, wherein

said layer material source is a linearly extending source elongated in a direction perpendicular to a direction of the relative movement between said mask and said layer material source, and said substrate.

9. A method according to claim 8, wherein

said linearly extending source is formed by a plurality of layer material sources arranged adjacent to each other.

10. A method according to claim 7, wherein

a semiconductor material is used for said mask.

11. A manufacturing method of a color emissive device including, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels, said method comprising the steps of:

disposing between said substrate and an emissive material source a mask including an opening at a position corresponding to a region for forming the emissive material layer of one or more of said plurality of pixels of said substrate; and

sliding a relative position between said mask and said emissive material source, and said substrate by a predetermined pitch corresponding to a size of the pixel of said substrate, and causing an emissive material to attach to a predetermined region of said substrate through said mask, thereby forming the emissive material layer.

12. A manufacturing method of a color emissive device according to claim 11, wherein

said substrate is slid in two directions of said substrate perpendicular to each other by a pitch corresponding to an arrangement of said pixels for a same color.

13. A manufacturing method of a color emissive device according to claim 11, wherein

said substrate is slid in one direction of said substrate by a pitch corresponding to an arrangement of said pixels for a same color.

14. A manufacturing method of a color emissive device according to claim 11, wherein

said emissive material source is a linearly extending source elongated in a direction perpendicular to a direction of the relative movement between said mask and said emissive material source, and said substrate.

15. A manufacturing method of a color emissive device according to claim 14, wherein

said linearly extending source is formed by a plurality of emissive material sources arranged adjacent to each other

16 A manufacturing method of a color emissive device according to claim 11, wherein

said self-emissive element is an electroluminescent element.

17 A manufacturing method of a color emissive device according to claim 11, wherein

said emissive device is a display device for displaying an image with a plurality of pixels

18 A manufacturing method of a color emissive device according to claim 11, wherein

a semiconductor material is used for said mask.

19 A manufacturing method of a color emissive device including, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels, said method comprising the steps of:

disposing between said substrate and an emissive material source a mask including an opening at a position corresponding to a region for forming the emissive material layer of one or more of said plurality of pixels of said substrate, and having a smaller area than said substrate to cover one or more of said plurality of pixels on said substrate; and

sliding a relative position between said mask and said emissive material source, and said substrate by a predetermined pitch corresponding to a size of the pixel of said substrate, and causing an emissive material to attach to a predetermined region of said substrate through said mask, thereby forming the emissive material layer

20 A manufacturing method of a color emissive device according to claim 19, wherein

said substrate is slid in two directions of said substrate perpendicular to each other by a pitch corresponding to an arrangement of said pixels for a same color.

21 A manufacturing method of a color emissive device according to claim 19, wherein

said substrate is slid in one direction of said substrate by a pitch corresponding to an arrangement of said pixels for a same color.

22 A manufacturing method of a color emissive device according to claim 19, wherein

said emissive material source is a linearly extending source elongated in a direction perpendicular to a direction of the relative movement between said mask and said emissive material source, and said substrate

23 A manufacturing method of a color emissive device according to claim 22, wherein

said linearly extending source is formed by a plurality of emissive material sources arranged adjacent to each other

24 A manufacturing method of a color emissive device according to claim 19, wherein

a semiconductor material is used for said mask.

25 A manufacturing method of a display device including, on a substrate, a self-emissive element having a first electrode, an emissive material layer for each color, and a second electrode, for each of a plurality of pixels, said method comprising the steps of:

disposing between said substrate and an emissive material source a mask including an individual opening for each pixel corresponding to a region for forming the emissive material layer individually patterned for each of said plurality of pixels; and

sliding a relative position between said emissive material source and said substrate and causing an emissive material to attach to a predetermined region of said substrate through the opening of said mask, thereby forming the emissive material layer

26 A manufacturing method of a display device according to claim 25, wherein

said emissive material source is a linearly extending source elongated in one direction

* * * * *

US 20020179013A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0179013 A1**
Kido et al. (43) **Pub. Date: Dec. 5, 2002**

(54) **SUCCESSIVE VAPOUR DEPOSITION SYSTEM, VAPOUR DEPOSITION SYSTEM, AND VAPOUR DEPOSITION PROCESS**

(76) Inventors: **Junji Kido**, Nara-ken (JP); **Tokio Mizukami**, Kanagawa ken (JP)

Correspondence Address:
McCormick, Paulding & Huber
City Place II
185 Asylum Street
Hartford, CT 06103-3402 (US)

(21) Appl No : **10/152,697**

(22) Filed: **May 22, 2002**

(30) **Foreign Application Priority Data**

May 23, 2001 (JP) 2001-153367

Publication Classification

(51) **Int. Cl.**^{7} **C23C 16/00**

(52) **U.S. Cl.** **118/718**; 118/715; 118/726

(57) **ABSTRACT**

A successive vapor deposition system in which a vapor deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate, includes a conveyer which conveys the substrate in a conveying direction parallel to a plane on which the substrate lies, wherein the vapor deposition area faces downward and is exposed through the underside of the conveyer; a plurality of vapor deposition chambers aligned in the conveying direction, each the vapor deposition chamber including a space through which the substrate is conveyed; at least one container positioned in each of the plurality of vapor deposition chambers below the plane on which the substrate lies, and containing the vapor deposition material, wherein a width of the container covers the vapor deposition area in a direction perpendicular to the conveying direction; and a heating medium provided for the container

1

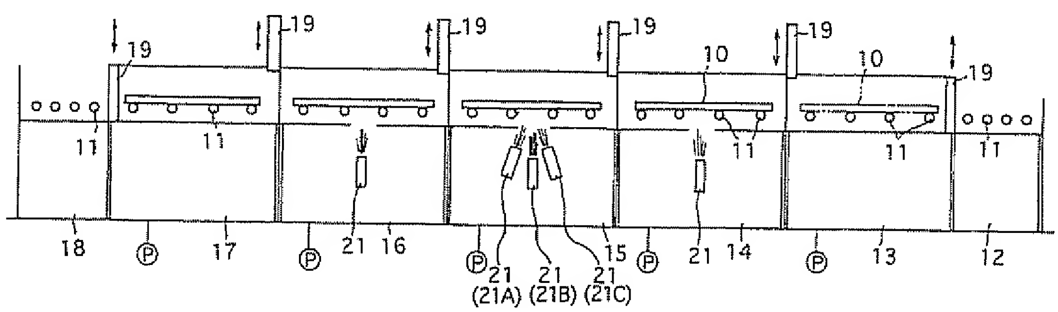
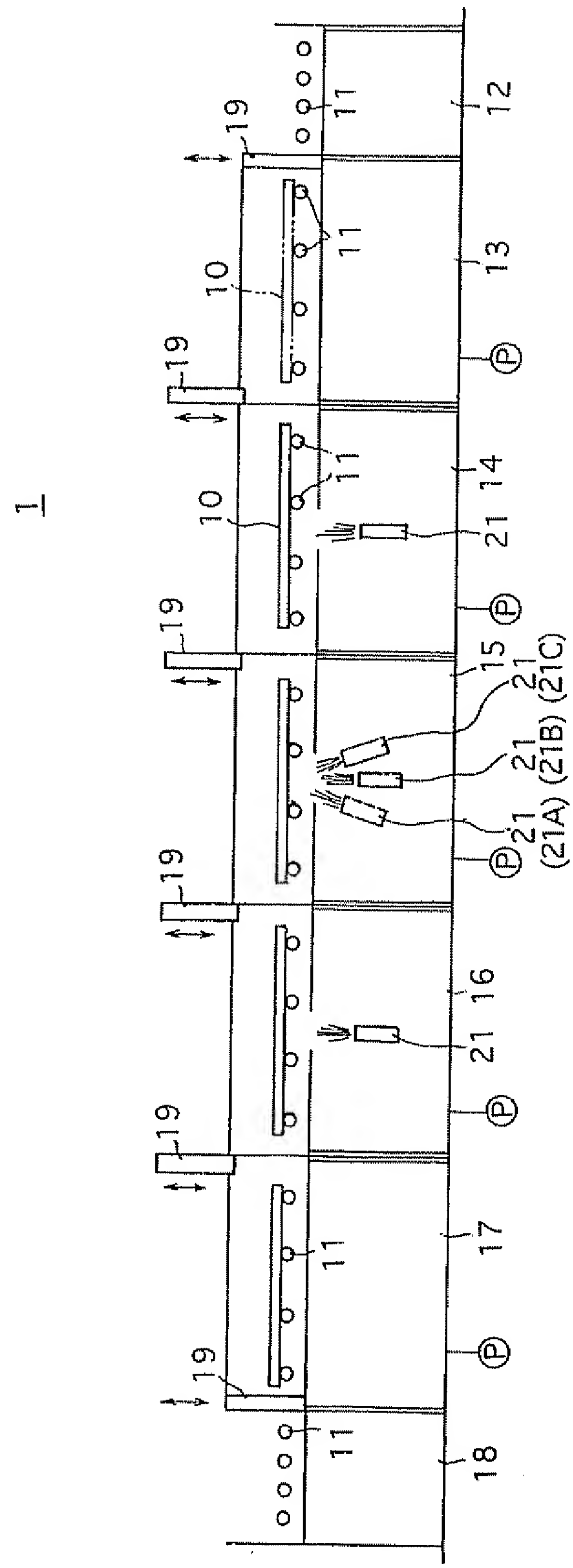


Fig. 1



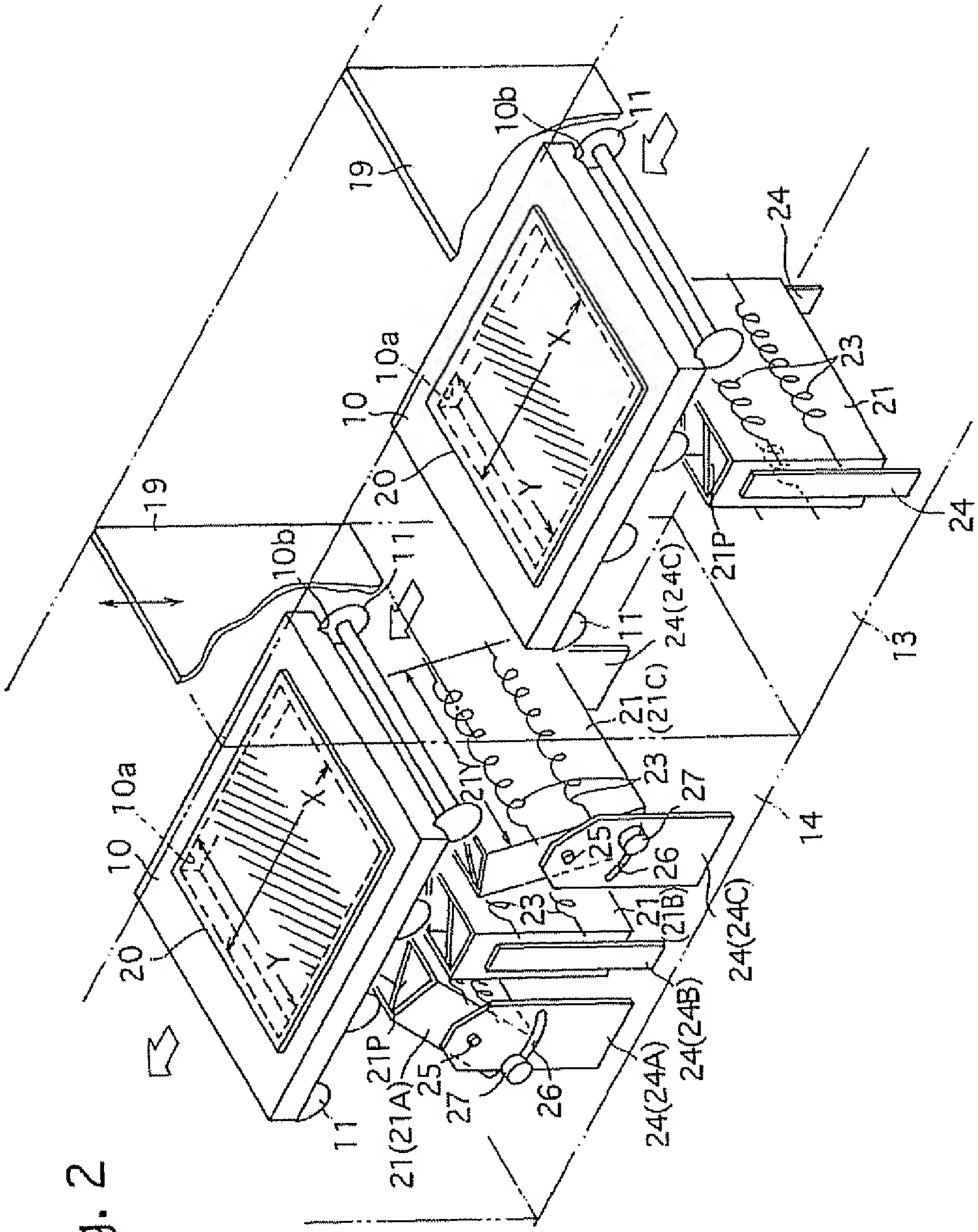

10
10a
10b
11
13
14
19
20
21
21(21A)
21(21B)
21(21C)
21P
21Y
23
24
24(24A)
24(24B)
24(24C)
25
26
27
X
Y

Fig. 2

Fig. 3

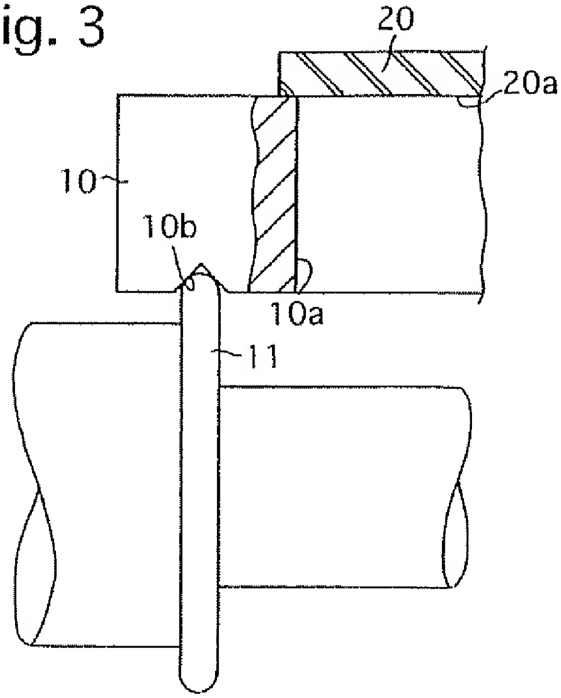


Fig. 4A

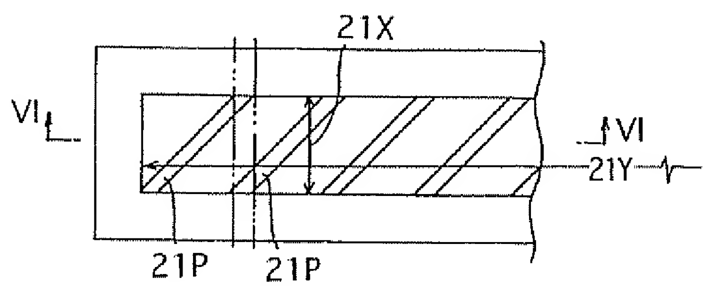


Fig. 4B

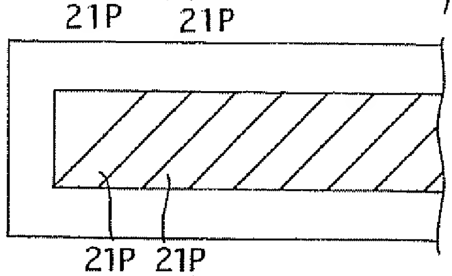


Fig. 4C

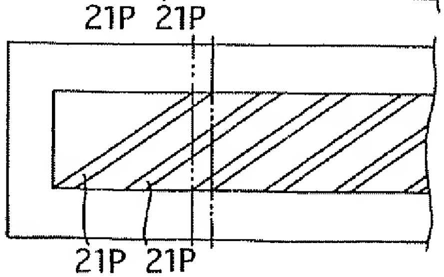


Fig. 5

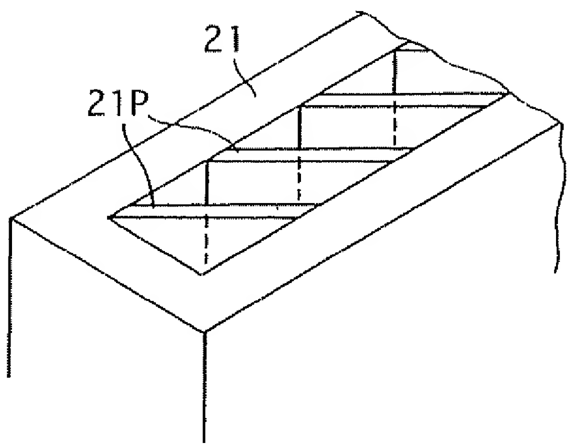


Fig. 6

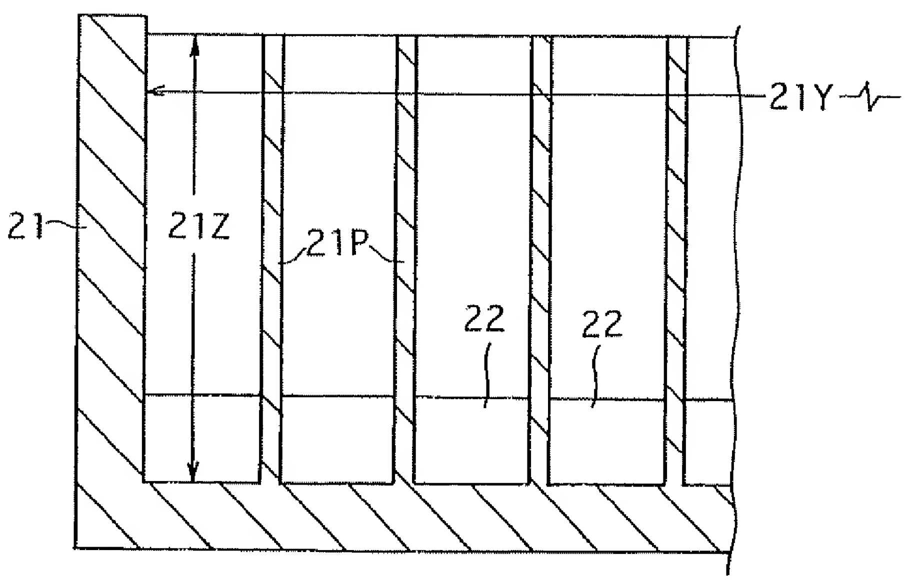
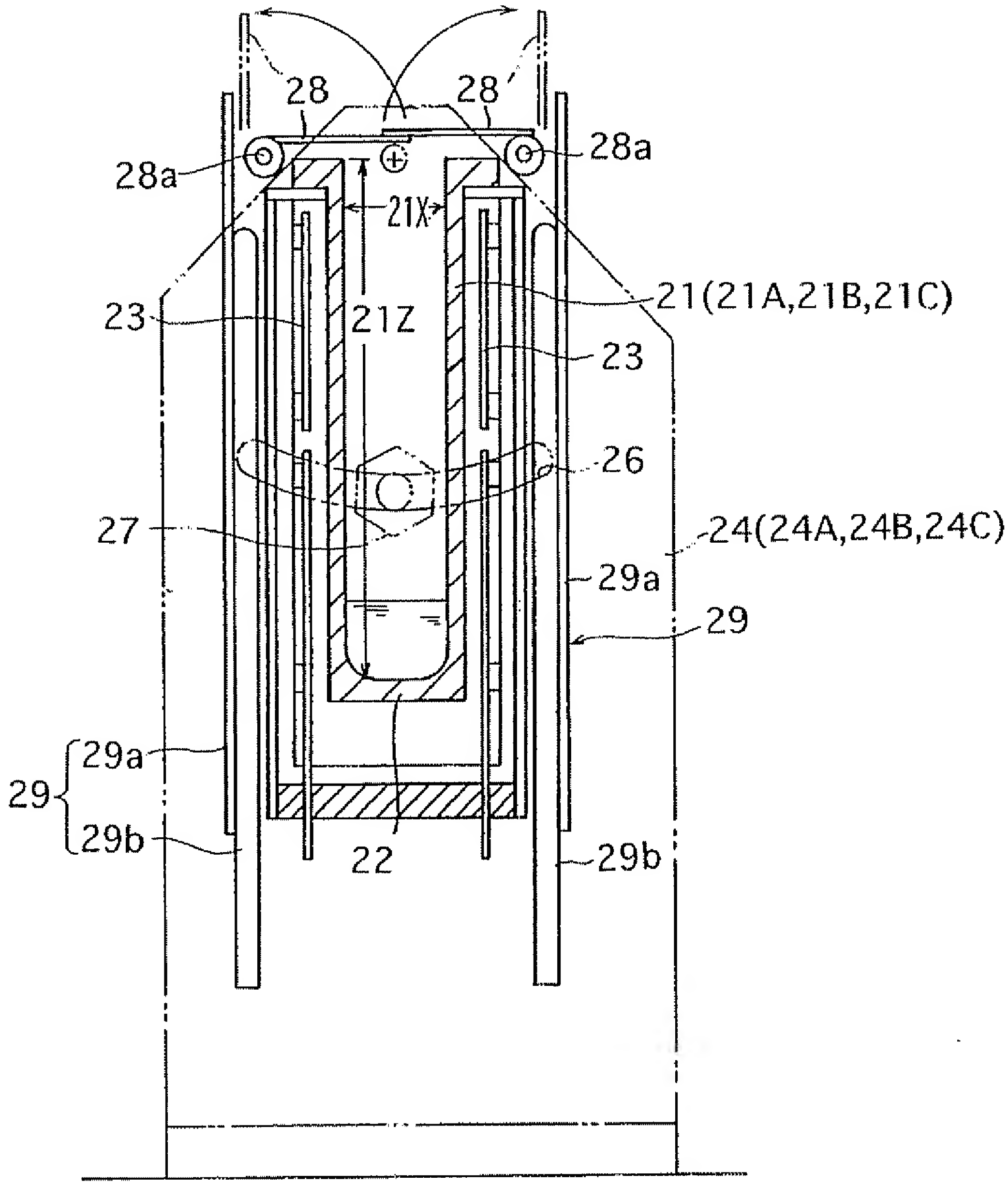


Fig. 7


28
28
28a
28a
21X
21(21A,21B,21C)
23
21Z
23
26
27
24(24A,24B,24C)
29a
29
29a
29
29b
22
29b

SUCCESSIVE VAPOUR DEPOSITION SYSTEM, VAPOUR DEPOSITION SYSTEM, AND VAPOUR DEPOSITION PROCESS

BACKGROUND OF THE INVENTION

[0001] 1 Field of the Invention

[0002] The present invention relates to a successive vapor deposition system suitable for successive formation of thin layers of different vapor deposition materials onto a substrate. The present invention also relates to a vapor deposition system and a vapor deposition process.

[0003] 2. Description of the Related Art

[0004] A typical organic electroluminescent device generally has a hole-transporting layer, a luminescent layer, an electron-transporting layer and an electrode layer which are formed by vacuum deposition successively on an ITO (Indium tin oxide) glass substrate In conventional successive vapor deposition systems for forming such successive layers on the glass substrate, a plurality of vacuum deposition chambers (which include a substrate stock chamber and a preliminary treatment chamber) for evaporating different vapor deposition materials onto the glass substrate are arranged radially with respect to a central vacuum carrier robotic chamber, so that the glass substrate is successively transferred from one chamber to another among the plurality of vacuum deposition chambers via a robotic system of the central vacuum carrier robotic chamber to form thin layers of the different materials on the glass substrate

[0005] In such conventional successive vapor deposition systems, the substrate needs to be successively displaced from one chamber to another, among the plurality of vacuum deposition chambers, via the central vacuum carrier robotic chamber, which is a time-consuming and inefficient operation. In addition, vapor deposition materials are consumed excessively because of the fundamental structure of the conventional systems in which vacuum deposition chambers are merely arranged around the central vacuum carrier robotic chamber Specifically, in such conventional successive vapor deposition systems, different vapor deposition materials and the substrate are respectively arranged on lower and upper areas in a vacuum deposition chamber, and the different vapor deposition materials are heated to be vaporized (or sublimed) while the substrate is being rotated on its axis or revolved around the axis of the central vacuum carrier robotic chamber to form layers of the different vapor deposition materials entirely on one side of the substrate with a substantially even layer thickness However, an excessive consumption of the vapor deposition materials cannot be avoided because the evenness of the layers is ensured only by depositing a portion of vaporized molecules onto the substrate, the vaporized molecules of which are spread out widely upwards in all directions from crucibles or boats, each of which is approximately regarded as a point source of evaporation In other words, an excessive consumption of the vapor deposition materials cannot be avoided because most of the vaporized molecules are deposited onto inner walls of the vacuum deposition chambers; only a few percent of the vaporized molecules is deposited onto the substrate in practice. Some vapor deposition materials used in production of organic electroluminescent devices are extremely expensive, e.g., tens of thousands of yen per gram Accordingly, an excessive consumption of the vapor deposition materials causes a substantial increase in the cost of production

[0006] In an organic electroluminescent device, a host material and at least one dopant material are generally co-deposited on the substrate at a specific ratio (e g., a ratio of 100 to 1, or a ratio of 100 to 0 5) in order to determine the luminescent color of an organic luminescent layer However, in conventional organic electro-luminescent devices, most of such different materials are wasted, and further, it becomes difficult to retain the specific ratio over time

SUMMARY OF THE INVENTION

[0007] The present invention is devised in view of the problems noted above, and accordingly provides a vapor deposition system which makes it possible to form layers of vapor deposition materials on a substrate successively with efficiency of time, and with a minimum waste of the vapor deposition materials

[0008] The present invention also provides a vapor deposition system which makes it possible to co-deposit different vapor deposition materials onto a substrate to form layers of the different vapor deposition materials thereon at a specific ratio with a minimum fluctuation thereof.

[0009] For example, in an aspect of the present invention, a successive vapor deposition system is provided, in which at least one vapor deposition material is heated, vaporized in a vacuum, and deposited onto an area to be deposited (hereinafter, a vapor deposition area) of a substrate The successive vapor deposition system includes a conveyer which conveys the substrate in a conveying direction parallel to a horizontal plane on which the substrate lies; a plurality of vapor deposition chambers aligned in the conveying direction; at least one container positioned, in each of the plurality of vapor deposition chambers, below the horizontal plane on which the substrate lies; and a heating medium provided for the container.

[0010] The vapor deposition area of the substrate faces downward and is exposed through the underside of the conveyer Each of the vapor deposition chambers includes a space through which the substrate is conveyed in the conveying direction The container contains the vapor deposition material, and the width thereof covers the vapor deposition area in a direction perpendicular to the conveying direction

[0011] A plurality of containers for containing the vapor deposition material can be positioned in at least one of the plurality of vapor deposition chambers. The top openings of the plurality of containers extend in a direction perpendicular to the conveying direction so that respective vaporized materials ascending from the plurality of containers are co-deposited onto a common area on the vapor deposition area of the substrate

[0012] At least one of the plurality of containers is adjustably tilted at a desired angle relative to another container in order to define the common area

[0013] According to another aspect of the present invention, the vapor deposition system is provided with a single vapor deposition chamber in which at least one vapor

deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate

[0014] The conveyer conveys the substrate in a vapor deposition chamber in the conveying direction parallel to the horizontal plane on which the substrate lies, while the vapor deposition area faces downward and is exposed through the underside of the conveyer The container is provided, in the vapor deposition chamber, below the horizontal plane on which the substrate lies, and contains the vapor deposition material The width of the container covers the vapor deposition area in a direction perpendicular to the conveying direction The heating medium is provided for the container for heating the vapor deposition material

[0015] As still another aspect of the present invention, the vapor deposition system can be used as an independent co-deposition system In this aspect of the present invention, a plurality of the containers, which are provided in a vapor deposition chamber, are arranged so that respective vaporized materials ascending from the plurality of containers are co-deposited onto a common area on the vapor deposition area of the substrate. Moreover, at least one of the plurality of containers is adjustably tilted at a desired angle relative to another container in order to define the common area in the vapor deposition area of the substrate.

[0016] In regard to the container, a depth of the container is determined so that the vapor deposition material to be vaporized which is contained therein can ascend in a direction of the depth of the container and toward the vapor deposition area of the substrate According to this arrangement, the vapor deposition material is vaporized on the vapor deposition area of the substrate by utilizing directivity of molecules of the vapor deposition material due to the so-called chimney effect; however, it is understood, in the prior art, that a container (a crucible) for containing a vapor deposition material designed to have the chimney effect is not preferable, when attempting to achieve an even-layer forming on the vapor deposition area.

[0017] Furthermore, as long as the container is designed to cover the whole vapor deposition area in a direction perpendicular to the conveying direction, any type of container, such as single-type container or a separate-type container, can be utilized

[0018] In the case where a single-type container is employed, a container having the shape of a rectangular box elongated in a direction perpendicular to the conveying direction is preferable In other words, the crucible, which is formed as explained, can cover the vapor deposition area in the direction perpendicular to the conveying direction with the minimum length of the crucible

[0019] Furthermore, it is preferable that the inner space of the crucible be partitioned by a plurality of partitions in order to heat the vapor deposition material uniformly More specifically, the partition extend parallel to each other in a direction oblique to the conveying direction so that a layer of the vapor deposition material is formed uniformly on the vapor deposition area On the other hand, if the partitions extend parallel to the conveying direction, the density of molecules of the vapor deposition material just above the partitions becomes sparse due to the chimney effect, even under the condition that the heat can be uniformly applied to the vapor deposition material It is understood that a plurality of partitions is equivalent to plural containers arranged in a direction perpendicular to the conveying direction, and that a container in which the vapor deposition material is provided can be separated into plural containers

[0020] As a further aspect, the present invention can be applied to a vapor deposition process in which at least one vapor deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate. The vapor deposition process comprising the following steps of:

[0021] conveying the substrate into an inner space of at least one vapor deposition chamber in a conveying direction parallel to a horizontal plane on which the substrate lies, while the vapor deposition area faces downward and is exposed via an opening in the underside of the conveyer;

[0022] positioning the substrate, in the inner space of the vapor deposition chamber, above at least one container which contains the vapor deposition material, is positioned in the inner space of the vapor deposition chamber, and the width of which covers the vapor deposition area in a direction perpendicular to the conveying direction; and

[0023] heating the container to evaporate the vapor deposition material onto the vapor deposition area.

[0024] In the vapor deposition process described above, a plurality of vapor deposition chambers can be provided in the conveying direction along which a substrate to be deposited is conveyed A container is positioned in each of the vapor deposition chambers, and the heating can be performed in each of the vapor deposition chambers in order to vaporize the vapor deposition material contained therein.

[0025] In the vapor deposition process described above, a plurality of the containers can be provided in a vapor deposition chamber In each of the containers, different vapor deposition materials are provided therein. Each of the containers is independently heated so that the different vapor deposition materials can be vaporized

[0026] The vapor deposition materials used in the successive vapor deposition system, the vapor deposition system or the vapor deposition process according to the present invention can be any vapor deposition materials as long as they can be vaporized via the application of heat. Such vapor deposition materials can be, e.g., any known functional organic-thin-layer forming material used for the formation of layers of an organic electroluminescent device, an organic solar battery or an organic FET (field effect transistor) Such vapor deposition materials can also be, e.g., a metal, or any known inorganic compound material such as oxide, nitride, carbide or halogenide Typical organic materials of the luminescent layer or the electron-transporting layer of the organic electroluminescent device include tris(8-hydroxyquinoline)aluminum complex compound (commonly called "Alq_3") Typical organic materials of the hole-transporting layer of the organic electroluminescent device include arylamine compounds such as N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-diphenyl-4,4'-diamine (commonly called "TPD")

[0027] On the other hand, typical inorganic materials used for the organic electroluminescent device include inorganic

compound materials such as metal halide, and also include aluminum, magnesium and silver that are mainly used as materials for an electrode. It should be noted that the present invention does not concern the vapor deposition materials, accordingly, other examples of organic or inorganic materials used for the formation of layers of the organic electroluminescent device are not herein disclosed

[0028] The present disclosure relates to subject matter contained in Japanese Patent Application No 2001-153367 (filed on May 23, 2001) which is expressly incorporated herein by reference in its entirety

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The present invention will be described below in detail with reference to the accompanying drawings in which:

[0030] **FIG. 1** is a general side view of an embodiment of a successive vapor deposition system according to the present invention;

[0031] **FIG. 2** is a perspective view of a fundamental portion of the successive vapor deposition system shown in **FIG. 1**;

[0032] **FIG. 3** is a partial cross-section of a fundamental portion of a transfer system for the transfer of substrates;

[0033] **FIGS. 4A, 4B** and 4C are plan views of examples of a crucible provided in the successive vapor deposition system shown in **FIG. 1**, showing examples of the structure of partitions formed therein;

[0034] **FIG. 5** is a perspective view of the crucible shown in **FIG. 4A**;

[0035] **FIG. 6** is a cross sectional view of the crucible shown in **FIG. 4A**, taken along VI-VI line in **FIG. 4A**; and

[0036] **FIG. 7** is a longitudinal cross sectional view of the crucible.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] **FIG. 1** shows an embodiment of a successive vapor deposition system according to the present invention. The successive vapor deposition system **1** is provided with a plurality of substrate holders **10** and a plurality of conveying rollers **11** which conveys the substrate holders **10** from right to left as viewed in **FIG. 1**. The plurality of substrate holders **10** and the plurality of conveying rollers **11** constitute a conveyer The plurality of conveying rollers **11** are driven by a motor (not shown) The successive vapor deposition system **1** is provided, in a conveying direction of the substrate holders **10** (the horizontal-leftward direction as viewed in **FIG. 1**; hereinafter referred to as "conveying direction"), with a preparation stage **12**, a preliminary vacuum chamber **13**, a first vapor deposition chamber **14**, a second vapor deposition chamber (co-deposition chamber) **15**, a third vapor deposition chamber **16**, a preliminary ejection chamber **17** and an ejection stage **18**, in this order from right to left as viewed in **FIG. 1** Each of the chambers **13** through **17** includes a space (conveyance space) through which the substrate holders **10** are conveyed in the conveying direction, and is partitioned so that vacuum in the chamber can be controlled via a corresponding gate **19** independently of the other chambers Namely, the successive vapor deposition system **1** is provided for each of the chambers **13** through **17** with a vacuum pump P so that the degree of vacuum in each of the chambers **13** through **17** can be controlled with the associated vacuum pump P. Each gate **19** can be controlled to open only during the conveyance of one substrate holder **10** from the previous chamber (or stage) to the subsequent chamber (or stage) in the conveying direction Alternatively, each gate **19** can remain opened at all times if the substrates (not shown in **FIG. 1**) held by the substrate holders **10** are successively conveyed thereby for mass production. Conventional techniques are used for the formation and the operation of each of the chambers **13** through **17**. The successive vapor deposition system **1** is preferably provided in a clean room

[0038] As shown in **FIGS. 2** and **3**, each substrate holder **10** is provided, at a center thereof with a rectangular opening **10*a***, and is further provided, on an bottom surface thereof, with a pair of V-grooves **10*b*** which extend parallel to each other in the conveying direction As shown in **FIG. 3**, a glass substrate **20** is mounted on each substrate holder **10** with an area **20*a*** to be vapor-deposited (hereinafter, an vapor-deposition area) **20*a*** of the glass substrate **20** being open (exposed) to the underside of the substrate holder **10** via the opening **10*a***. The vapor deposition area **20*a*** is defined by the opening **10*a*** as a rectangular area having a length X in the conveying direction and a width Y in a direction perpendicular to the conveying direction. Although one glass substrate **20** is mounted on one substrate holder **10** in the illustrated embodiment, more than one glass substrate **20** can be mounted on one substrate holder **10** in accordance with the size of the glass substrate **20**

[0039] Accordingly, when the conveying rollers **11** are driven, the glass substrate **20**, in which the vapor deposition area **20*a*** is exposed to the underside of the associated substrate holder **10** via the opening **10*a*** thereof, is conveyed from the preparation stage **12** to the ejection stage **18** in sequence via the intervening chambers **13, 14, 15, 16** and **17**

[0040] If the size of the vapor deposition area **20*a*** needs to be defined by a shadow mask (not shown), the shadow mask can be integrated with the substrate holder **10**.

[0041] In the illustrated embodiment shown in **FIG. 1**, the successive vapor deposition system **1** is provided, in each of the first and third deposition chambers **14** and **16** below a horizontal plane on which the substrate holders **10** lie, with a container (crucible) **21** The successive vapor deposition system **1** is provided, in the second vapor deposition chamber (co-deposition chamber) **15**, with three crucibles **21** (**21A, 21B** and **21C**) These five crucibles **21** have basically the same structure, and each crucible **21** is in the shape of a rectangular box elongated in a direction perpendicular to the conveying direction. Forming the crucible **21** as explained is advantageous, since the vapor deposition area **20*a*** can be covered by the minimum length (width) of the crucible **21** in the direction perpendicular to the conveying direction In other words, as long as a crucible **21** is designed to have the above advantage, other factors of a crucible **21**, such as the shape and orientation thereof, have some degree of freedom

[0042] Each crucible **21** is designed so that an inner length **21Y** (see **FIGS. 2, 4A** and **6**) thereof in a direction perpendicular to the conveying direction is slightly greater than the width Y of the vapor deposition area **20*a*** Namely, the inner

length 21Y is determined so that the crucible 21 fully covers the vapor deposition area 20a (the width Y) in a direction perpendicular to the conveying direction.

[0043] In addition, a depth 21Z (see FIGS. 6 and 7) of each crucible 21 is determined so that the vapor deposition material 22 contained in the crucible 21 to be vaporized by the application of heat can ascend in a direction of the depth 21Z within the crucible 21 (toward the vapor deposition area 20a) efficiently. In other words, this arrangement is to obtain the chimney effect on the vaporized material 22. Likewise, in order to obtain the chimney effect, the amount of the vapor deposition material 22 contained in the crucible 21 is set at a small amount. An inner width 21X of each crucible 21 is preferably determined to be smaller than each of the inner length 21Y and the depth 21Z so that the layer formed on the vapor deposition area 20a does not become uneven in the conveying direction.

[0044] The inner space of each crucible 21 is partitioned by a plurality of partitions 21P. FIGS. 4A, 4B and 4C show different examples of the way to partition the inner space of each crucible 21. The partitions 21P are formed in each crucible 21 for the purpose of applying heat to the vapor deposition material 22 in the crucible 21 uniformly to thereby vaporize the vapor deposition material 22 uniformly. The partitions 21P extend parallel to one another but do not extend parallel to the conveying direction. Namely, the partitions 21P extend parallel to one another in a direction oblique to the conveying direction. This oblique arrangement of the partitions 21P is advantageous to form a layer of the vapor deposition material uniformly on the vapor deposition area 20a because each point on the vapor deposition area 20a can passes over at least one partition of each crucible 21 so that the vaporized material ascending therefrom can reliably be deposited onto the vapor deposition area 20a. Hence, the angle of inclination of the partitions 21P and the spacing therebetween are determined so that a layer of the vapor deposition material is formed uniformly. Each crucible 21, together with the partitions 21P thereof, is preferably made of a high thermal conductive material (e.g., a material having a thermal conductivity of at least 1W/m*K) such as carbon.

[0045] The vapor deposition material 22 contained in each crucible 21 is precisely weighed to be distributed equally among the partitions in each crucible 21. If the vapor deposition material 22 is not distributed equally among the partitions in each crucible 21, the density of molecules of the vapor deposition material vaporized from each partition becomes uneven with time even if the temperature distribution of the vaporized vapor deposition material 22 is even in a direction perpendicular to the conveying direction, i.e., in the direction of the inner length 21Y. This makes it difficult to ensure the evenness of the layer of the vapor deposition material over the whole vapor deposition area 20a.

[0046] As shown in FIGS. 2 and 7, the successive vapor deposition system 1 is provided, around each crucible 21, with some filaments (heating wires) 23 serving as a heating medium. The temperature of each crucible 21 can be controlled by adjusting the electric current applied to the filaments 23.

[0047] Each of the two crucibles 21 provided in the first and third vapor deposition chambers 14 and 16 is fixed to a pair of stationary vertical plates 24 to be held vertically therebetween. Specifically, if a central plane of each crucible 21 is defined as a plane which passes through the center of the inner width 21X of the crucible 21 in a direction of the depth 21Z, each of the two crucibles 21 is fixed to the associated pair of vertical plates 24 so that the central plane extends in a direction perpendicular to the vapor deposition areas 20a of the glass substrates 20, which are conveyed in a horizontal direction. On the other hand, regarding the remaining three crucibles 21 (21A, 21B and 21C) provided in the second vapor deposition chamber (co-deposition chamber) 15, the respective rectangular top openings of the three crucibles 21 (21A, 21B and 21C) extend in a direction perpendicular to the conveying direction so that the respective vaporized materials ascending from the three crucibles 21 (21A, 21B and 21C) are co-deposited onto a common area on the vapor deposition area 20a of each glass substrate 20. In particular, the central crucible 21B is fixed to a pair of stationary vertical plates 24 (24B) to be held vertically therebetween in a manner similar to that of each of the two crucibles 21 provided in the first and third vapor deposition chambers 14 and 16, while each of the other two crucibles 21 (21A and 21C) is rotatably held between a pair of stationary vertical plates 24 (24A or 24C) about a shaft 25 which extends in a direction perpendicular to the conveying direction, so that the angle of inclination of each of the two crucibles 21A and 21C relative to the central crucible 21B is adjustable about the shaft 25. One of the pair of stationary vertical plates 24A which supports the crucible 21A is provided with a circular arc slot 26 which extends about the associated shaft 25, and the crucible 21A is provided with a set screw 27 which passes through the circular arc slot 26 to be screwed into the crucible 21A (see FIGS. 1 and 7). Likewise, one of the pair of stationary vertical plates 24C that supports the crucible 21C is provided with a circular arc slot 26 which extends about the associated shaft 25, while the crucible 21C is provided with a set screw 27 which passes through the circular arc slot 26 to be screwed into the crucible 21C (see FIGS. 1 and 7). Accordingly, such angle-adjusting structures of the two crucibles 21A and 21C make it possible to co-deposit the respective vaporized materials ascending from the three crucibles 21 (21A, 21B and 21C) onto a common area on the vapor deposition area 20a of each glass substrate 20. In practice, the respective angles of the two crucibles 21A and 21C relative to the central crucible 21B are preferably adjusted so that the central plane of each of the two crucibles 21A and 21C intersects the central plane of the central crucible 21B at a straight line on the vapor deposition area 20a of a given glass substrate 20. The ideal angles of the two crucibles 21A and 21C relative to the central crucible 21B can be easily determined by experimentation.

[0048] As shown in FIG. 7, the successive vapor deposition system 1 is provided, at the top of each crucible 21, with a double-doored shutter 28 for opening and closing the open top of the crucible 21, and/or is provided, around each crucible 21, with a water-cooled jacket 29 (both the double-door shutter 28 and the water-cooled jacket 29 are shown in FIG. 7). The double-doored shutter 28 is provided with a pair of shutter plates, each pivoted at a corresponding pivot 28a to open and close the open top of the crucible 21. For instance, the double-doored shutter 28 opens at the time the temperature of the associated crucible 21 (the vapor deposition material 22) reaches a predetermined temperature, and at the same time when a glass substrate 20 is being conveyed

to be positioned above the associated crucible **21**; and the shutter **28** closes at all other times. The water-cooled jacket **29** is provided with a panel **29a** which surrounds the crucible **21** with a predetermined gap between the panel **29a** and the crucible **21**, and is further provided, on an inner surface of the panel **29a**, with a cooling tube **29b** in which cooling water travels to minimize the effect of the radiation of heat from the crucible **21** on peripheral devices of the system **1** when the temperature of the crucible **21** rises The water-cooled jacket **29** can be used together with the filaments **23** to serve as a temperature controller for controlling the temperature of the associated crucible **21** (the vapor deposition material **22**) A film-thickness detection monitor and a controller therefor, which are available on the market, can be provided on an upper end of each crucible **21** so as not to overlap the vapor deposition area **20a** of the glass substrate **20** positioned above the crucible **21** Due to this arrangement, the value of the electric current applied to the filaments **23** can be controlled by the film-thickness detection monitor and the controller therefor, so that a desired accumulation speed is obtained by monitoring the accumulation speed during the process of evaporation of the vapor deposition material onto the vapor deposition area **20a**

[0049] The successive vapor deposition system **1** that has the above described structure can be used as a system for manufacturing red-light-emitting organic electroluminescent devices in the following manner:

[0050] ITO glass substrates, on which a transparent electrode (ITO serving as an anode) has been formed in advance, are used as the glass substrates **20**;

[0051] TPD which serves as a material of a hole-transporting layer of the organic electroluminescent device is provided in the crucible **21** in the first vapor deposition chamber **14**;

[0052] Alq_3 which serves as a host material of a luminescent layer is provided in the central crucible **21B** in the second vapor deposition chamber **15**;

[0053] Rubrene which serves as a dopant material for yellow is provided in the crucible **21A** in the second vapor deposition chamber **15**; and

[0054] DCM2 which serves as a dopant material for red is provided in the crucible **21C** in the second vapor deposition chamber **15**

[0055] In this particular case, for the purpose of making DCM2 which serves as a red-light emission material emit light efficiently, rubrene is used to serve as an auxiliary dopant material for transferring excitation energy generated from Alq_3, which serves as host material, to DCM2 smoothly. At this time, the temperatures of the crucibles **21A**, **21B** and **21C** in the second vapor deposition chamber (co-deposition chamber) **15** are controlled independently of each other so that the aforementioned rubrene, Alq_3 and DCM2 which are respectively contained in the crucibles **21A**, **21B** and **21C** are vaporized to be co-deposited onto the vapor deposition area **20a** of each glass substrate **20** at a desired mixture ratio Alq_3 which serves as a material of an electron transporting layer is provided in the crucible **21** in the third vapor deposition chamber **16**

[0056] After such vapor deposition materials have been contained in the five crucibles **21**, layer-forming operations (vapor deposition operations) are performed in the following manner

[0057] First of all, each of the preliminary vacuum chamber **13**, the first through third vapor deposition chambers **14**, **15** and **16**, and the preliminary ejection chamber **17** is exhausted to a predetermined degree of vacuum, and the respective crucible is heated to a predetermined temperature in advance In this state, each of the glass substrates **20** mounted on the substrate holders **10** is firstly brought into the first vapor deposition chamber **14** so that the vaporized material (TPD) ascending therefrom is deposited onto the vapor deposition area **20a** to form a hole-transporting layer thereon

[0058] Subsequently, the glass substrate **20** on which the hole-transporting layer has been formed is brought into the second vapor deposition chamber (co-deposition chamber) **15** so that the three vaporized materials (rubrene, Alq_3 and DCM2) ascending therefrom are co-deposited onto the vapor deposition area **20a** to form a luminescent layer on the hole-transporting layer. The ratio (co-deposition ratio) of the accumulation speed of the vapor deposition material from the crucible **21A**, to the accumulation speed of the vapor deposition material from the crucible **21B**, and to the accumulation speed of the vapor deposition material from the crucible **21C** can be precisely controlled by controlling the heating temperatures of the crucibles **21A**, **21B** and **21C** so that the accumulation speed of the vapor deposition material from each of the crucibles **21A**, **21B** and **21C** which is monitored by the associated film thickness detection monitor becomes a desired speed

[0059] Furthermore, the glass substrate **20** on which the luminescent layer has been formed is brought into the third vapor deposition chamber **16** so that the vaporized material (Alq_3) ascending therefrom is deposited onto the vapor deposition area **20a** to form an electron-transporting layer thereon If other layers such as an electrode layer serving as a cathode needs to be formed on each glass substrate **20**, the successive vapor deposition system **1** only needs to add one or more additional vapor deposition chambers

[0060] In the present embodiment of the successive vapor deposition system **1** in which thin layers of different vapor deposition materials are co-deposited onto each glass substrate **20** uniformly as the glass substrates **20** are conveyed linearly, the control of the layer thickness can be achieved by controlling the accumulation speeds detected by the aforementioned film thickness detection monitor and also the conveying speed of the glass substrates **20** In this case, the layer thickness can be controlled by moving the glass substrates **20** back and forth intentionally so that the glass substrates **20** reciprocate above the crucibles **21** and by adjusting the number of the reciprocating motions and the moving speed of the glass substrates **20** This control can be combined with the layer thickness control using the double-doored shutter **28**, which is provided at the top of the crucibles **21**

[0061] Unlike a conventional successive vapor deposition system in which substrates are successively transferred from one chamber to another among a plurality of vacuum deposition chambers via a robotic system of a central vacuum carrier robotic chamber positioned at the center of the plurality of vacuum deposition chambers, the above-described layer forming process has the following features:

- **[0062]** (1) layers of vapor deposition materials can be successively formed onto the vapor deposition area **20a** of each glass substrate **20** as the glass plates **20** are conveyed in the conveying direction;

[0063] (2) a layer of each vapor deposition material can be formed on a large vapor deposition area easily because each entire layer can be formed on the vapor deposition area **20***a* of each glass substrate **20** at the same time in the direction of the width Y (see **FIG. 2**) of the vapor deposition area **20***a*;

[0064] (3) different vapor deposition materials can be vaporized to be co-deposited entirely onto the vapor deposition area **20***a* of each glass substrate **20** to form a layer of the different vapor deposition materials at a given precise ratio (co-deposition ratio); and

[0065] (4) a layer of each vapor deposition material can be formed on the vapor deposition area **20***a* of each glass substrate **20** with minimum waste of the vapor deposition materials

[0066] Although the above illustrated embodiment of the successive vapor deposition system is provided with a plurality of vapor deposition chambers (**14**, **15** and **16**), it is possible to provide a vapor deposition system including only one vapor deposition chamber corresponding to one of the first and third vapor deposition chambers **14** and **16** According to this vapor deposition system, a vapor deposition material can be deposited onto the vapor deposition area **20***a* of each glass substrate **20** with minimum waste of the vapor deposition material. Moreover, it is possible to provide a vapor deposition system including only one vapor deposition chamber corresponding to the second vapor deposition chamber (co-deposition chamber) **15**. According to this vapor deposition system, different vapor deposition materials can be co-deposited onto the vapor deposition area **20***a* of each glass substrate **20** with minimum waste of the vapor deposition materials while the co-deposition ratio can be controlled precisely

[0067] In the above illustrated embodiment of the successive vapor deposition system, a process of depositing different organic substances onto an ITO glass substrate to form the hole-transporting layer, a luminescent layer and the electron-transporting layer successively on the ITO glass substrate has been discussed A cathode layer needs to be formed on the electron-transporting layer to provide an organic electroluminescent device as a completed product. Since a vapor deposition area of the glass substrate onto which a material of the cathode layer is deposited is not identical to that onto which the organic substances of the hole-transporting layer, the luminescent layer, and the electron-transporting layer are deposited, it is generally the case that a vapor deposition area of the glass substrate on which the organic substances are deposited is defined by a shadow mask (or a member having both a function of a shadow mask and also a function of a substrate holder on which the glass substrate is mounted) A mechanism for placing, removing, replacing and/or positioning such a shadow mask or dual-function member is known in the art, and is not related to the purpose of the present invention Accordingly, a process of forming the cathode layer on the electron-transporting layer is not herein discussed The cathode layer can be formed on the electron-transporting layer in a manner similar to the above described manner of forming another layer on the glass substrate after a vapor deposition area of the glass substrate, onto which a material of the cathode layer is deposited, is defined. Although the inner space of each crucible **21** is partitioned by the plurality of partitions **21P** which extend in a direction oblique to the conveying direction, the present invention is not limited solely to this particular arrangement. Namely, the plurality of crucibles can be arranged in a direction perpendicular to the conveying direction

[0068] As can be understood from the foregoing, according to the present invention, a vapor deposition system which makes it possible to form layers of vapor deposition materials on a substrate successively with efficiency and with minimum waste of the vapor deposition materials is achieved Moreover, a vapor deposition system which makes it possible to form a layer of a vapor deposition material on a substrate with minimum waste of the vapor deposition material is achieved Furthermore, a vapor deposition system which makes it possible to co-deposit different vapor deposition materials onto a substrate to form layers of different vapor deposition materials thereon at a specific ratio with minimum waste of the vapor deposition materials is achieved

[0069] Obvious changes may be made in the specific embodiment of the present invention described herein, such modifications being within the spirit and scope of the invention claimed It is indicated that all matter contained herein is illustrative and does not limit the scope of the present invention

What is claimed is:

1 A successive vapor deposition system in which at least one vapor deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate, said successive vapor deposition system comprising:

a conveyer which conveys said substrate in a conveying direction parallel to a horizontal plane on which said substrate lies, wherein said vapor deposition area faces downward and is exposed through the underside of said conveyer;

a plurality of vapor deposition chambers aligned in said conveying direction, wherein each of said vapor deposition chambers comprises a space through which said substrate is conveyed in said conveying direction;

at least one container positioned, in each of said plurality of vapor deposition chambers, below said horizontal plane on which said substrate lies, and containing said vapor deposition material, wherein a width of said container covers said vapor deposition area in a direction perpendicular to said conveying direction; and

a heating medium provided for said at least one container for heating said vapor deposition material

2 The successive vapor deposition system according to claim 1, wherein at least one of said plurality of vapor deposition chambers are provided with said at least two containers provided therein, and wherein respective top openings of said plurality of containers extend in a direction perpendicular to said conveying direction so that respective vaporized materials ascending from said plurality of containers are co-deposited onto a common area on said vapor deposition area of said substrate

3. The successive vapor deposition system according to claim 2, wherein at least one of said plurality of containers is adjustably tilted at a desired angle relative to other containers in order to define said common area.

4. The successive vapor deposition system according to claim 1, wherein a depth of said at least one container is determined so that said vapor deposition material to be

vaporized which is contained in said container ascends in a direction of said depth through said container and toward said vapor deposition area of said substrate

5 The successive vapor deposition system according to claim 1, wherein said at least one container comprises a plurality of partitions which partition an inner space of said at least one container.

6 The successive vapor deposition system according to claim 5, wherein said plurality of partitions extend parallel to each other in a direction oblique to said conveying direction

7 The successive vapor deposition system according to claim 1, wherein said vapor deposition material comprises at least one of an organic substance, a metal, and an inorganic compound.

8 The successive vapor deposition system according to claim 7, wherein said successive vapor deposition system is used to form at least one layer of an organic electroluminescent device

9. The vapor deposition system according to claim 1, wherein said conveyer comprises at least one substrate holder on which said substrate is mounted, and wherein an opening is formed on said substrate holder so that said vapor deposition area is exposed through the underside of said substrate holder via said opening

10 A vapor deposition system in which at lease one vapor deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate, said vapor deposition system comprising:

a conveyer which conveys said substrate in a vapor deposition chamber in a conveying direction parallel to a horizontal plane on which said substrate lies, wherein said vapor deposition area faces downward and is exposed through the underside of said conveyer;

at least one container positioned, in said vapor deposition chamber, below said horizontal plane on which said substrate lies, and containing said vapor deposition material, wherein a width of said container covers said vapor deposition area in a direction perpendicular to said conveying direction; and

a heating medium provided for said container for heating said vapor deposition material

11 The vapor deposition system according to claim 10, wherein said at least two containers are provided, and wherein respective top openings of said plurality of containers extend in a direction perpendicular to said conveying direction so that respective vaporized materials ascending from said plurality of containers are co-deposited onto a common area on said vapor deposition area of said substrate

12 The vapor deposition system according to claim 11, wherein at least one of said plurality of containers is adjustably tilted at a desired angle relative to other containers in order to define said common area

13 The vapor deposition system according to claim 10, wherein a depth of said container is determined so that said vapor deposition material to be vaporized which is contained in said container ascends in a direction of said depth through said container and toward said vapor deposition area of said substrate

14 The vapor deposition system according to claim 10, wherein said container comprises a plurality of partitions which partition an inner space of said container

15 The vapor deposition system according to claim 14, wherein said plurality of partitions extend parallel to each other in a direction oblique to said conveying direction

16 The vapor deposition system according to claim 10, wherein said vapor deposition material comprises at least one of an organic substance, a metal and an inorganic compound.

17. The vapor deposition system according to claim 10, wherein said vapor deposition system is used to form at least one layer of an organic electroluminescent device

18 The vapor deposition system according to claim 10, wherein said conveyer comprises at least one substrate holder on which said substrate is mounted, and wherein an opening is formed on said substrate holder so that said vapor deposition area is exposed through the underside of said substrate holder via said opening.

19. A vapor deposition process in which at least one vapor deposition material is heated, vaporized in a vacuum, and deposited onto a vapor deposition area of a substrate, said vapor deposition process comprising:

conveying said substrate into an inner space of at least one vapor deposition chamber in a conveying direction parallel to a horizontal plane on which said substrate lies, wherein said vapor deposition area faces downward and is exposed via an opening in the underside of said conveyer;

positioning said substrate, in said inner space of said vapor deposition chamber, above at least one container positioned in said inner space of said vapor deposition chamber, said container containing said vapor deposition material, wherein a width of said container covers said vapor deposition area in a direction perpendicular to said conveying direction; and

heating, said container to evaporate said vapor deposition material onto said vapor deposition area.

20 The vapor deposition process according to claim 19, wherein said at least two vapor deposition chambers are aligned in said conveying direction, said container being positioned in each of said plurality of vapor deposition chambers; and wherein said heating is performed in each of said containers so that said vapor deposition material is vaporized to be co-deposited on said vapor deposition area of said substrate

21. The vapor deposition process according to claim 19, wherein said at least one vapor deposition material comprises a plurality of different vapor deposition materials;

wherein said at least two containers, which respectively contain said plurality of different vapor deposition materials, are provided, and said plurality of containers are positioned in one of said plurality of vapor deposition chambers; and

wherein each of said plurality of containers is heated so that said plurality of different vapor deposition materials are vaporized to be co-deposited onto a common are on said vapor deposition area of said substrate.

22 The vapor deposition process according to claim 19, wherein said vapor deposition process is performed so as to form at least one layer of an organic electroluminescent device

* * * * *

27.2: Linear Source Deposition of Organic Layers for Full-Color OLED

Steven Van Slyke, Angelo Pignata, Dennis Freeman, Neil Redden
Eastman Kodak Company, Rochester, NY USA

Dave Waters, H. Kikuchi, T. Negishi
Ulvac Japan, Ltd., Chigasaki, Japan

H. Kanno, Y. Nishio, M. Nakai
Sanyo Electric Company, Ltd., Gifu, Japan

Abstract

A key requirement for fabrication of organic light emitting diode (OLED) displays is uniform film deposition over large areas because of the sensitivity of emission color and efficiency on film thickness Conventional deposition using point sources is unattractive because of the requirement of a large source to substrate separation. usually with substrate rotation. to achieve acceptable thin film uniformity. By translating a novel extended linear evaporation source in a single direction. film non-uniformity of less than 5% has been demonstrated over a 300 mm x 400 mm substrate with a source to substrate separation of 100 mm

OLEDs with all organic layers deposited using linear sources have been determined to operate identically to devices fabricated using conventional point sources The performance of doped and undoped devices as well as the advantages of linear source deposition over conventional deposition techniques will be described.

1. Introduction

Since the discovery of efficient electroluminescence from organic thin films [1], progress in materials and configurations has resulted in high efficiency red [2], green [3], and blue [4] emitting single-pixel test devices with excellent operational stability characteristics. Organic light emitting diode (OLED) display devices have also been developed, with passive matrix monochrome devices being commercialized in 1997 [5] and full-color active matrix displays expected to be mass produced in 2002 [6]. OLED displays appear to be ideal for low, as well as high information content hand-held applications, and are expected to become widely adopted in cellular telephones where performance features of wide-angle viewing, high contrast, low power, thin structure, and fast response time are important.

Although significant device progress has been realized, continuous improvements in fabrication methods are necessary in order to attain high manufacturing yield. One critical issue is that of organic thin film deposition. Film thickness uniformity over large substrate areas is important because of the pronounced emission spectral dependence on layer thickness [7]. Highly uniform deposition can, of course, be achieved by a large source to substrate separation and substrate rotation, however, this becomes unattractive as the substrate size is increased and the vacuum chamber required becomes proportionally larger. Additionally, as the source to substrate separation increases, the fraction of material that deposits on the substrate is reduced, with the result being both a poor deposition yield and the need for frequent chamber maintenance

A novel extended linear source has been developed that offers significant advantages over the conventional point source deposition approach. Figure 1 is a schematic drawing of a linear source and substrate. The source is operated by establishing the deposition rate in a position remote from the substrate (home) and scanning the source under the substrate as shown. Uniformity in the Y-axis direction is achieved by appropriate design of the linear source so that a uniform vapor flux is attained along its length. Uniformity along the X-axis is achieved by maintaining both a constant source emission rate as the source is scanned and a controlled scan rate. Typically, the source is scanned under the substrate twice (one round trip), returning to the home position for adjustment of the deposition rate while another substrate is loaded into the deposition chamber.

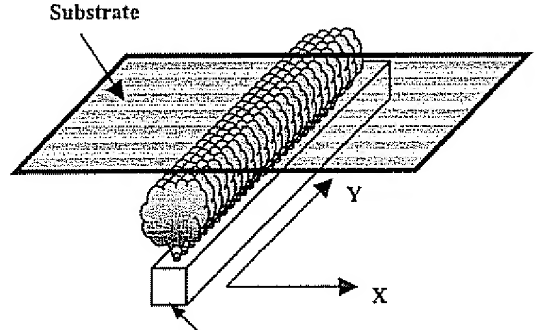


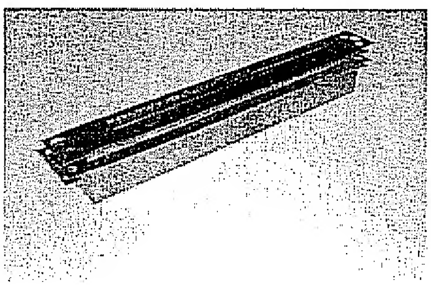
Figure 1. Schematic of linear source and substrate. The source is translated in the X direction during a coating operation. Of course, a system could also be designed where the substrate moves over a stationary linear source.

While uniformity is clearly important, device performance cannot be compromised by the method of organic thin film deposition. This paper describes deposition uniformity as well as operating performance of OLED devices fabricated using novel linear sources.

 ISSN/0002-0966X/02/3302-0886-$1.00+.00

2. Linear Source Design

A photograph and a cross sectional drawing of the linear source [8] is shown in Figure 2. The organic material is placed in the quartz boat and heated by a bias (bottom) and primary (top) heater. The bottom heater, fabricated from tantalum, is used to de-gas and heat the organic material to a temperature below the vaporization temperature, typically about 200°C. The top heater, also tantalum, is operated at a temperature sufficient to vaporize the upper surface of the organic powder by radiative heating, avoiding the necessity to heat the entire source charge to the vaporization temperature. Typically, the bottom heater temperature is kept constant during deposition and the top heater temperature is adjusted to attain the desired source vapor emission rate. The vaporized organic material exits the source through the aperture in the top heater. A baffle is incorporated in the top heater to prevent "spitting" of particles, which is of particular importance for OLED devices because of the thin film structure and sensitivity to electrical shorting.



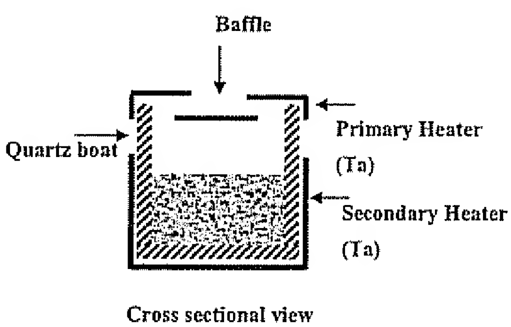


Figure 2. Linear source showing primary heater, secondary heater and quartz boat. The source shown is 25 mm (W) x 25 mm (H) x 250 mm (L). The 500 mm source has the same cross-sectional area and differs from the 250 mm source only in length.

Two source sizes have been evaluated. For device fabrication, the quartz boat length was 250 mm with an aperture length of 200 mm, designed for deposition on 152.4 mm square substrates. A longer source, designed for coating 300 mm wide substrates and used for evaluating source emission uniformity, incorporated a 500 mm long quartz boat and 440 mm long aperture. For both source styles, all other dimensions (height, width, quartz thickness, etc.) were the same.

3. Linear Source Uniformity (500 mm source)

The deposition uniformity from the 500 mm source was evaluated by monitoring the deposition rate above the source using a linear multi-sensor array of quartz crystal oscillators. The eight sensors were arranged at 68.5 mm intervals, placed 100 mm above and in line with the linear source aperture. Figure 3 shows the normalized deposition rate of Alq as a function of position. The deposition rate was approximately 50 Å/s and the non-uniformity is within 5% over the central 300 mm region. The rate decreases rapidly beyond 300 mm, with the deposition rate at the outermost sensors being about half that of the central 300 mm sensors. The source design is critical for achieving this uniformity and was optimized for deposition uniformity over 300 mm using the 440 mm aperture.

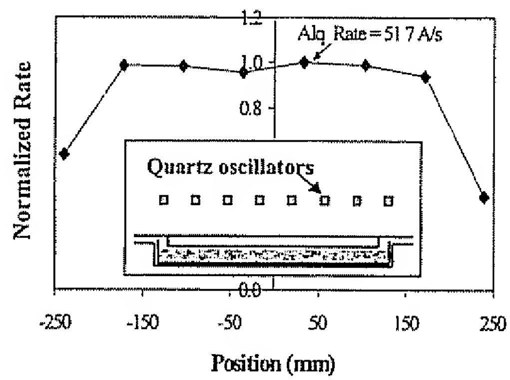
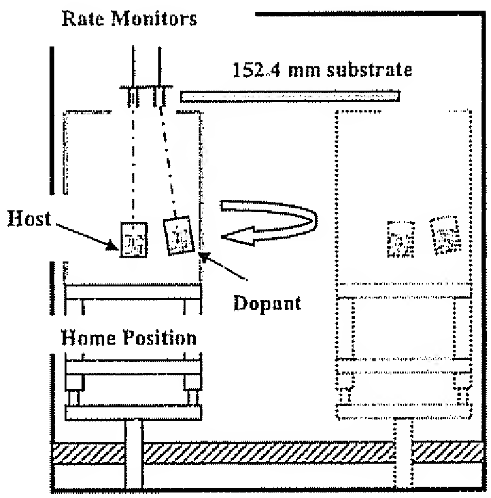


Figure 3. Deposition rate as a function of position from a 500 mm linear source. The non-uniformity over the central 300 mm portion is less than 5%. The inset is a schematic drawing of the source and sensor head array configuration.

4. Device Fabrication

4.1 Experimental Details

Linear sources for hole transport and emitting layer deposition were installed in a vacuum chamber as shown schematically in Figure 4. For the hole transporting layer, a single linear source was installed, and for the emitting layer, a host source and a dopant source were positioned adjacently so both sources could be operated simultaneously to form a mixed layer. The source to substrate separation was 100 mm. The deposition rates were adjusted in the "home" position and once the appropriate rate was established, the source was scanned below the substrate. The deposition rates were set at levels comparable to the rates expected for mass production. The deposition was completed in one "round trip", and the source was then kept in the home position until another substrate was loaded into the chamber. Because of space constraints in the vacuum chamber, a chimney with a 43 mm wide opening was installed to avoid errant deposition on the substrate when in the extreme travel positions. In manufacturing, the coating chamber would be designed so that the restriction in the chimney would not be necessary.



Side View

Figure 4. Schematic drawing of source assembly in vacuum chamber. The source length is 250 mm and the source to substrate separation is 100 mm. The source assembly is translated approximately 190 mm during deposition, returning to the home position to form the full layer thickness.

In the same vacuum chamber, point sources were installed so that control devices could be fabricated for direct comparison with the linear source fabricated devices. The sources were located directly below the substrate and the source to substrate separation was 406 mm.

The 152.4 mm square substrates were loaded into the vacuum chamber through a load lock and, after organic film deposition, were placed in a cathode deposition chamber where 1000 Å of MgAg was deposited at 10:1 Å/s. Devices fabricated using the linear sources and control devices fabricated using point sources were deposited on the same substrate and during the same pumpdown cycle to minimize substrate-to-substrate variability. In all cases, the test devices were 0.1cm^2 single pixels.

4.2 Rate Dependence

Test devices with the configuration ITO/NPB (1500 Å)/Alq (750 Å)/MgAg were fabricated using linear and point sources for both NPB and Alq. For linear source deposition rates from 16 Å/s to 256 Å/s, the performance characteristics (efficiency, drive voltage and stability) were essentially identical to the point source controls. For example, Figure 5 shows the operational stability of the linear source prepared device with the highest NPB and Alq deposition rates (higher by ~4x over what is estimated for manufacturing). Operating at 20 mA/cm^2 constant current density, the luminance degradation curves are similar, indicating that linear source deposition is equivalent to the standard point source method for both NPB and Alq. The increase in drive voltage is also the same for both devices, with about 0.5 V rise observed during the test.

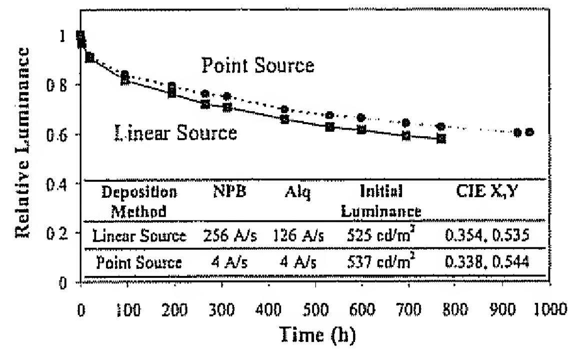


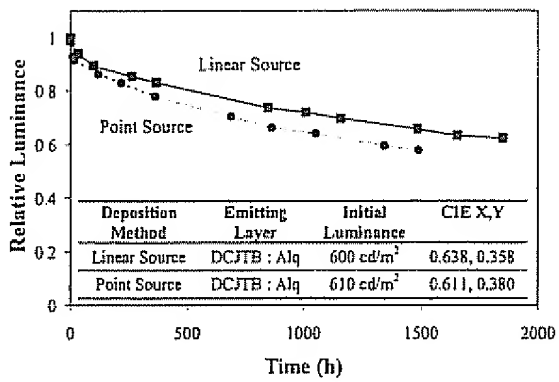
Figure 5. ITO/NPB/Alq/MgAg devices fabricated using linear sources and point sources for the organic layers.

4.3 Device Performance: Red, Green, and Blue Doped Structures

Red, green, and blue devices were fabricated with a device structure of ITO/NPB/EL/ETL/MgAg where EL is the emitting layer and ETL is the electron transporting layer. The hole transporting NPB layer was 1500 Å thick and was deposited on all quadrants simultaneously, from either a point source or a linear source (as shown in the last section, the NPB by point source and linear source methods gives similar results). The EL was deposited either by the linear source or point source method on the appropriate quadrant by selectively masking the substrate during deposition. The ETL was Alq from a point source, also deposited simultaneously on all quadrants. The thickness of the combined EL and ETL layer was about 750 Å for all three colors.

For all stability tests, the devices were operated at a constant average current density of 20 mA/cm^2. This was achieved by applying a 40 mA/cm^2 constant current pulse alternating with a 14 V reverse bias pulse (50% duty cycle) at 1 kHz.

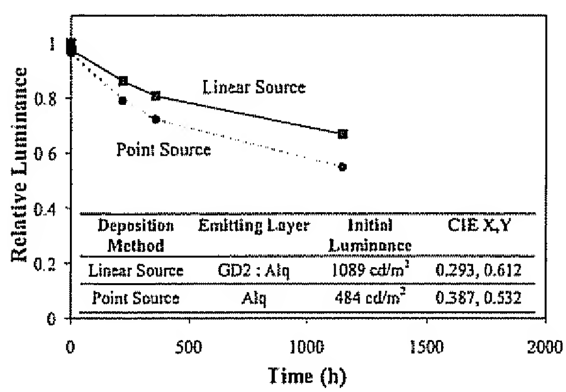
The performance of the red emitting device is shown in Figure 6. The linear source deposition rate of the EL was 50 Å/s for the Alq host and approximately 0.65 Å/s for the DCJTB dopant. The point source control Alq and DCJTB deposition rates were 4 Å/s and approximately 0.04 Å/s, respectively. The efficiency of the linear source prepared device was 3 cd/A, essentially the same as the point source control. The operational stability plots show that the linear source prepared devices are slightly more stable than the controls, with a luminance loss of about 40% after 2000 h of continuous operation.



Deposition Method	Emitting Layer	Initial Luminance	CIE X,Y
Linear Source	DCJTB : Alq	600 cd/m²	0.638, 0.358
Point Source	DCJTB : Alq	610 cd/m²	0.611, 0.380

Figure 6. Red emitting devices fabricated using linear and point source methods.

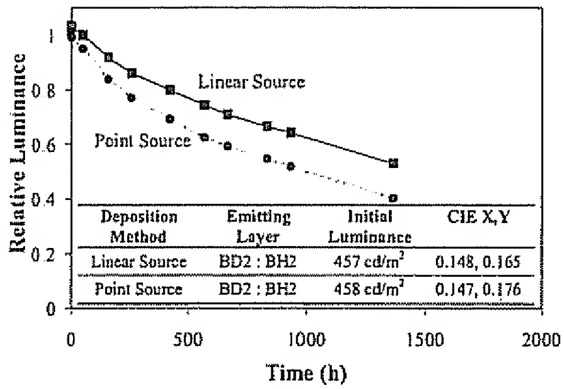
The performance of the green emitting device is shown in Figure 7 The linear source deposition rate was 45 Å/s for the host Alq and about 1 Å/s for the GD2 dopant. In this experiment, the control was undoped Alq deposited at 4 Å/s As with the red emitting device, the operational stability of the linear source prepared device is slightly improved compared to the point source control and degrades by about 40% after 1300 h of operation from an initial luminance of 1089 cd/m^2.



Deposition Method	Emitting Layer	Initial Luminance	CIE X,Y
Linear Source	GD2 : Alq	1089 cd/m²	0.293, 0.612
Point Source	Alq	484 cd/m²	0.387, 0.532

Figure 7. Green emitting devices fabricated using linear and point source methods.

The blue device prepared by the linear source method is compared with the point source controls in Figure 8. The deposition rate of the blue host (BH2) was 50 Å/s and the blue dopant (BD2) rate was 0.6 Å/s. The point source controls were the same composition, with the BH2 deposited at 4 Å/s. For both methods, the CIE chromaticity and efficiency (2.3 cd/A) were similar. As with the red and green emitting devices, the linear source prepared devices show a slight stability improvement compared to the control, with a degradation of about 50% after 1400 h.



Deposition Method	Emitting Layer	Initial Luminance	CIE X,Y
Linear Source	BD2 : BH2	457 cd/m²	0.148, 0.165
Point Source	BD2 : BH2	458 cd/m²	0.147, 0.176

Figure 8 Blue emitting devices fabricated using linear and point source methods.

5. Summary

A novel linear source useful for fabricating OLED displays has been described. The source is capable of providing high rate, uniform deposition over large areas, a key requirement for mass production. With a 100 mm source to substrate separation, non-uniformity of less than 5% has been demonstrated across a 300 mm width. The source design is expected to be extendable to larger areas, which will be required as next generation OLED display manufacturing lines are installed.

Simple two-layer undoped OLED devices have been fabricated using linear sources at deposition rates from 16 to 256 Å/s and show essentially identical performance to point source prepared devices. Additionally, red, green, and blue doped OLED devices fabricated using linear sources exhibit the same or better operating characteristics compared to point source controls.

In conclusion, the linear sources described in this paper are well suited for mass production of full color OLED displays

6. Acknowledgements

The authors would like to thank Mei Yen, Gerry Kehoe, Tukaram K. Hatwar, G. Rajeswaran and H. Takahashi for device fabrication and valuable discussions

7. References

[1] C. W. Tang and S. A. Van Slyke, Appl. Phys Lett. 51, 913 (1987).

[2] C W Tang, S. A. Van Slyke, and C. H. Chen, J. Appl. Phys. 65, 3610 (1989).

[3] J. Shi and C. W. Tang, Appl. Phys. Lett. 70, 13 (1997).

[4] S. A Van Slyke, P S Bryan, and C W. Tang, in *Proceedings of the Electroluminescence Workshop* (Wissenschaft and Technic, Berlin, 1996) p. 195

[5] T Tohma, *Proc IDRC 1997*, F1-F4.

[6] G. Rajeswaran, M. Itoh, M. Boroson, S. Barry, T. K. Hatwar, K. B. Kahen, K. Yoneda, R. Yokoyama, T. Yamada, N. Komiya, H. Kanno, and H. Takahashi, SID 2000 Digest, pp. 974-977 (2000).

[7] Y. Fukuda, T. Watanabe, T. Wakimoto, S. Miyaguchi, and M. Tsuchida, Synthetic Metals, Vols. 111-116, 1, (2000)

[8] R. G. Spahn, US Patent 6,237,529.